AND

PROCEEDINGS

OF THE

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ERRATA.

Page 188 : *Struthiolaria convexa* plotype is from loc. 1089.

Plate 16 (facing page 192) : Figs. 11 and 12 are × 2, not × 1.

Page 646 : In text of fig. 14, for *Polyymoria* read *Polymoria.*

Page 657, line 6 : ***For*** ♀ ***read*** ♂ .

Page 660, line 3 : *For* pls. 27–28 *read* pls. 27–36.

Richard. F. L. Burton.

[Face p. vii

OBITUARY.

RICHARD FRANCIS LINGEN BURTON, 1865-1922.

RICHARD FRANCIS LINGEN BURTON, of Longner, died on the 7th January, 1922, after a lingering illness, aged fifty-seven. He was educated at Eton, Sandhurst, and Cirencester. He came to New Zealand in 1881 with his cousin, Mr. Pryce (Halcombe, N.Z.), to learn farming, and was for a time on one of Mr. Riddiford's stations, afterwards taking up land at Apiti. From here he explored the Ruahine Range. He also spent some time in Westland. Afterwards he visited New Guinea, and this brought him into association with Captain C. A. W. Monckton, who dedicated one of his books to Burton, describing him as "a crack shot, a fine boxer and fencer, afraid of nothing that either walked, flew, or swam, and crammed with a vast lore of out-of-the-way knowledge."

On succeeding to the family estates in 1902 he settled down to the life of an English squire and the management of one of the most ancient estates in Britain- for Longner Hall, Salop, is mentioned in Domesday. The management of his 3,000 Shropshire acres and his New Zealand run occupied much of his time, but he also found time to act on public bodies and carry out most painstaking observations on the insect-life of Shropshire, and the cultivation of many New Zealand plants, including orchids, from seed.

The publication of his observations has chiefly devolved on others. Theobald's *Monograph of the Culicidae* devotes several pages to Burton's observations on British mosquitoes, and he was of considerable assistance to the English authorities in their war-time studies on malarial mosquitoes. The *Entomologist* (June, 1922) states that he aided much in the compilation of the preliminary catalogue of English Diptera. *The Orchid Review* (April, 1922) stated that he was highly successful in the cultivation of British orchids. Much of his mosquito work has been published in Government Public Health Reports and in W. D. Lang's *Handbook* (1920; British Museum). To Shakespearian students he will be remembered as the discoverer of the Burton Shakespeare, containing the only perfect copy known of the 1599 edition of "Venus and Adonis," and the "Lucrece" of 1600, of which the only other perfect copy is in the Bodleian.

Burton had a charming personality, quick, nervous, and energetic, but unassuming, which endeared him to his friends. A tall, lean, blonde type of Englishman, he reminded you of an ancient Viking.

He was a most conscientious recorder of all natural phenomena which interested him, and it is to be hoped that his notebooks dealing with the cultivation of New Zealand plants may be examined and the observations published. He married in 1902 Miss Alice Mendelson, of Temuka. He is survived by his widow, a son, and several daughters. He was a life-member of the Wellington Philosophical Society.

B. C. ASTON.

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ROLL OF HONOUR

SHOWING MEMBERS OF THE INSTITUTE WHO WERE ON ACTIVE SERVICE DURING THE WAR.

Name.	Available Details of Service.	
	Wellington Philosophical Society.	
E. H. Atkinson ..	Lieutenant, Royal Naval Volunteer Reserve.	
C. M. Begg ..	Colonel, N.Z. Medical Corps	C.B., C.M.G. Died of sickne
Val. Blake ..	Lieutenant, Canterbury Infantry	Killed in actio
F. K. Broadgate ..	Lieutenant, N.Z. Engineers	Killed in actio
P. W. Burbidge ..	Sergeant, 34th Specialists.	
W. H. Carter ..	Canterbury Infantry.	
L. J. Comrie ..	Sergeant-Major, 36th Reinforcements.	
V. C. Davies ..	Regimental Sergeant-Major, 1st N.Z. Rifle Brigade	
W. Earnshaw ..	Engineer Lieut.-Commander, R.N.	
C. J. Freeman ..	N.Z. Rifle Brigade.	
C. Freyberg ..	Lieutenant, West York (Prince of Wales's Own) Regiment.	
J. G. B. Fulton ..	Corporal, 10th Reinforcements.	
H. E. Girdlestone..	Company Sergeant-Major, Wellington Infantry	Killed in actio
H. Hamilton ..	Sub-Lieutenant, Royal Naval Volunteer Reserve	
C. G. Johnston ..	Lieutenant, 1st N.Z. Rifle Brigade	Killed in actio
G. W. King ..	Lieutenant, N.Z. Tunnelling Company.	
E. Marsden ..	Major (temp.), N.Z. Engineers	M.C.; mention in despatche
J. M. Mason ..	Lieut.-Colonel, N.Z. Medical Corps.	
D. McKenzie ..	Trooper, Wellington Mounted Rifles.	
H. M. Millar ..	Sergeant, N.Z. Engineers' Divisional Signalling Company.	
W. L. Moore ..	Captain, N.Z. Field Artillery	Mentioned in despatches.
T. D. M. Stout ..	Lieut.-Colonel, N.Z. Medical Corps	D.S.O.
R. M. Sunley ..	Corporal, Specialists.	
W. M. Thomson ..	Captain, N.Z. Medical Corps.	
H. S. Tily ..	Sergeant, N.Z. Field Artillery.	
H. Vickerman ..	Major, commanding N.Z. Tunnelling Company	D.S.O., O.B.E.; mentioned in despatches.
C. J. Westland ..	Corporal, N.Z. Machine Gun Corps.	
	Auckland Institute.	
F. L. Armitage ..	Captain, N.Z. Medical Corps.	
S. B. Bowyer ..	Gunner, N.Z. Field Artillery.	
R. Briffault ..	Captain, N.Z. Medical Corps.	
P. H. Buck (Te Rangi Hiroa)	Major, N.Z. Medical Corps	D.S.O
S. Cory-Wright ..	Captain, N.Z. Engineers, Divisional Intelligence Officer	M.C
W. J. Crompton ..	1st Battalion, Otago Regiment.	
F. N. R. Downard	Lieutenant, N.Z. Rifle Brigade.	
G. Fenwick ..	Captain, N.Z. Medical Corps.	

Roll of Honour—*continued*

Name	Available Details of Service	
	Auckland Institute—*continued*	
R H Gunson	Lieutenant, Motor Boat Reserve	
G H Hansard	Sergeant Major, 33rd Machine Gun Corps	
D Holderness	Lieutenant, N Z Engineers	
R T Inglis	Captain, N Z Medical Corps	
J C Johnson	Captain, N Z Medical Corps.	
C W Leys	Lieutenant, Royal Naval Volunteer Reserve	
K Mackenzie	Captain, N Z Medical Corps	
H A E Milnes	Lieutenant, Auckland Infantry Regiment	Killed in action.
W R B Oliver	Corporal, Canterbury Infantry	
G Owen	Lieutenant, N Z Rifle Brigade and N Z Engineers	
A C Purchas	Major, N Z Medical Corps	
E Robertson	Captain, N Z Medical Corps	
C B Rossiter	Captain, N Z Medical Corps.	
I C Savage	Captain, N Z Medical Corps	Died of sickness
Rev D. Scott	Chaplains Department, N Z Expeditionary Force	
H L Wade	Captain, Auckland Mounted Rifles	
F Whittome	Corporal, N Z Rifle Brigade	
	Philosophical Institute of Canterbury	
H Acland	Colonel, N Z Medical Corps	
G E Archey	Captain, N Z Field Artillery	
J W Bird	Sergeant Major, Instructional Staff	
F J Borrie	Captain, N Z Medical Corps	
F M Corkill	Captain	
William Deans	Captain, Canterbury Mounted Rifles	
A A Dorrien Smith	Major	
A Fairbairn	Captain	
H D Ferrar	Trooper, N Z Mounted Rifles.	
C E Foweraker	Corporal, N Z Medical Corps	
F G Gibson	Captain, N Z Medical Corps	
J Guthrie	Captain, N Z Medical Corps	
W. Irving	Captain, N Z Medical Corps	
L S Jennings	Captain, Otago Regiment	Killed in action.
H Lang	2nd Lieutenant, N Z Rifle Brigade	Killed in action.
E Kidson	Captain, Royal Engineers	
G MacIndoe	Signaller, Otago Infantry Brigade	Killed in action
P S Nelson	Private, Canterbury Regiment	Killed in action
F S Oliver	Sergeant, Headquarters Instructional Staff	
H V Rowe	Sergeant Major Headquarters Instructional Staff.	
Sir R H Rhodes	Colonel, Red Cross Commissioner	
A Taylor	Captain, N Z Veterinary Corps	
G T Weston	Lieutenant, Canterbury Regiment	
F S Wilding	Captain, N Z Field Artillery	
J P Whetter	Captain, N Z Medical Corps	
A M Wright	Captain, N Z Medical Corps	
	Otago Institute.	
S C. Allen	Captain, N Z Medical Corps	
R. Buddle	Surgeon, H M Ships "Crescent," "Cumberland," and "Warwick"	Mentioned in despatches.
L. E Barnett	Lieut -Colonel, N Z Medical Corps	C.M.G.
F C. Batchelor	Lieut Colonel, N Z Medical Corps.	
Rev. D Dutton	Chaplain, N Z Expeditionary Force	
Cuthbert Fenwick	Sergeant, N Z Medical Corps.	
A. Mackie	Sergeant, N Z Expeditionary Force	M.M.

Roll of Honour—*continued.*

Name.	Available Details of Service.	
Otago Institute—*continued.*		
E. J. O'Neill ..	Lieut.-Colonel, N.Z. Medical Corps	C.M.G., D.S.O.
T. R. Overton ..	Lieutenant, N.Z. Pioneers.	
H. P. Pickerill ..	Lieut.-Colonel, N.Z. Medical Corps	O.B.E.
R. Price ..	Major, Otago Infantry	Killed in action.
E. F. Roberts ..	Captain, Royal Engineers.	
S. G. Sandle ..	Major, N.Z. Expeditionary Force.	
F. H. Statham ..	Major, Otago Infantry	Killed in action.
W. D. Stewart ..	Lieutenant, Otago Infantry.	
W. A. Thomson ..	N.Z. Machine Gun Corps.	
R. N. Vanes ..	Lieutenant, N.Z. Expeditionary Force.	
D. B. Waters ..	Captain, N.Z. Tunnelling Corps.	
H. F. H. Whitcombe	Gunner, N.Z. Field Artillery.	
Manawatu Philosophical Society.		
E. C. Barnett ..	Captain, N.Z. Medical Corps.	
D. H. B. Bett ..	Captain, N.Z. Medical Corps.	
A. A. Martin ..	Major, N.Z. Medical Corps	Killed in action.
J. Murray ..	Lieutenant, Auckland Infantry.	
H. D. Skinner ..	Private, Otago Infantry	D.C.M.
W. R. Stowe ..	Major, N.Z. Medical Corps.	
Hawke's Bay Philosophical Institute.		
H. F. Bornau ..	Captain, N.Z. Medical Corps.	
J. P. D. Leahy ..	Major, N.Z. Medical Corps.	
E. F. Northcroft ..	Corporal, 41st Reinforcements.	
E. G. Wheeler ..	Corporal, Wellington Regiment.	
G. T. Williams ..	Wellington Mounted Rifles	Died of sickness.
Nelson Institute.		
F. A. Bett ..	Captain, N.Z. Medical Corps.	
Wanganui Philosophical Society.		
Morris N. Watt ..	Corporal, N.Z. Medical Corps.	

Note.—The roll is as complete as it has been found possible to make it. The Editor would be glad to be notified of any omissions or necessary amendments.

PRESIDENTIAL ADDRESS.

THE following is the presidential address delivered before the New Zealand Institute on the 29th January, 1924, at Wellington, by Professor H. B. Kirk:—

In view of the fact that this meeting is essentially a business meeting, and that it has an immense amount of important work before it, my address must be a brief one, and it will touch only on certain points that seem to me to be of special importance to the Institute at the present time.

By the death of Mr. T. F. Cheeseman botanical science has lost one of its most earnest and efficient workers and one of its most capable leaders. At the time of his death he was completing the work of the second edition of the *Manual of the New Zealand Flora*. The work was practically ready for the press, and it will form a fitting crown to the achievements of a fruitful lifetime. Dr. Cockayne has prepared a note on Cheeseman's life and work, which appears in volume 54 of the *Transactions*.

One of the most distinguished of the honorary members of the Institute died in the early part of last year—Dr. Isaac Bayley Balfour, Keeper of the Royal Botanic Gardens at Edinburgh, and formerly Professor of Botany at Oxford and at Glasgow. Dr. Balfour was everywhere recognized as one of the leading botanists of the world, one of the finest and one of the most prolific workers in the field.

Among the delegates from Japan at the recent Pan-Pacific Congress was Dr. Fusakichi Omori, President of the Imperial Earthquake Investigation Committee of Tokyo, recognized as a first authority on seismology. He returned to Japan seriously ill, and died almost immediately after reaching his home. Although he was not an honorary member of the Institute, it is fitting that we should do honour to his memory, and a resolution will be submitted to you during the course of this meeting.

Among prominent members of the Institute that have died during the year were Professor F. D. Brown, Mr. R. Murdoch, and Mr. W. F. Worley.

The standing of the Institute in public esteem in New Zealand remains good, although the financial difficulties through which it has been passing have been very great. Especially great has been the strain put on the loyalty of the constituting societies by the necessity to curtail the *Transactions*, to maintain the levy, and generally to endeavour to discharge our financial liabilities, as well as by the long delay in the appearance of Volume 54 of the *Transactions*, which delay will presently be referred to. It is not strange that there has been occasional feeling of dissatisfaction on the part of some of the societies, but I do not think that feeling has ever been deep or that it has ever been other than transient. The societies have, on the whole, not failed to recognize that they are the Institute, and that its acts are in reality their own acts through their delegates, better informed than the majority of the members as to the work of the Institute, its needs and its difficulties.

The esteem in which the Institute is held would, I believe, be increased if it were to adopt the policy it has once or twice considered of making its annual meeting a scientific as well as a business meeting every second or third year. The success of this plan both at Christchurch and at

Palmerston North gives every encouragement. Such meetings are, without doubt, highly stimulating, and they serve to bring the members of the Institute more in touch with each other, enabling them to realize more fully the greatness of their common aim. At present many members recognize only that they are members of their local society, and fail to realize that they belong to the association of the scientific men of the land.

The standing of the Institute abroad continues to improve from year to year, if one may judge from the increasing number of applications from learned societies and scientific libraries to be placed on the exchange list.

Something might, I think, be done by the Institute to extend a welcome to the many scientific visitors that come to New Zealand without formal introductions to scientific men here. At present these visitors do not always know how to get in touch with those they would most like to meet. Those that are members of University staffs naturally seek out their coadjutors here, and they are in no difficulty; but many that are not professionally employed in scientific work feel diffident in taking the time of men that they, perhaps flatteringly, regard as busy. Help might be given to these visitors, and received from them, if an inset in the *Transactions* informed them that application to the office of the Institute, whether personally or in writing, would result in their being placed in communication with the workers they would most like to meet. In this connection, one of the most pressing needs is a suitable building in the city, easily found and likely to be noticed by those that are not looking for it. Such a building would meet also the very urgent need of the Institute for room in which to store its stocks of *Transactions* and other matters.

The long delay in the appearance of Volume 54 of the *Transactions* has been calculated to damage the prestige of the Institute both at home and abroad. From 1888 onwards the annual volume has been printed at the Government Printing Office, and the work has always been done well. It has been understood that the manuscript must be in the printer's hands early in the year, in order that the Institute's work might not clash with the enormous mass of work involved by the parliamentary session, and the early preparation of the manuscript has not been neglected by the Institute's Honorary Editor. For many years the Printing Office got the work of the volume out of hand in good time. Gradually, however, more and more of the other work of the office came to take precedence of the volume, until its issue was pushed late into the year, then into the early part of the following year, and now it happens that the volume containing the papers read in 1921 is only just ready to leave the Printing Office. The effect on the Institute has been exceedingly bad. Many members of the various societies join only because of the value they set on the *Transactions* · scientific papers published in the *Transactions* are not available to workers in other parts of the world until the volume is distributed, except in so far as the authors' "separates" are issued in advance of the volume: thus the tendency to send important work abroad for publication has increased, and the value of the volume and the prestige of the Institute have suffered. The Board of Governors has several times considered the advisability of again getting the volume printed by a private firm, but has always been faced by the difficulty that, owing to the recent high price of printing, it was in debt to the Government Printer. Now, in the improved circumstances referred to in the report of the Publication Committee, it will be possible to consider the question without the embarrassing feeling that we should be leaving the Government Office while still under a financial obligation to it. If the Board decides that a change ought to

be made, the decision will certainly be come to with regret, seeing how good the general work of the Government Office has been, and particularly how efficient the reading has always been. But the responsibility resting upon the Board to see that the work of the Institute is done with the utmost promptitude may well outweigh this feeling.

The Institute has continued, so far as it was able, to keep a watchful eye on matters affecting the preservation of the native fauna and flora. In connection especially with the extension in 1922 of the Tongariro National Park, the members of the Institute took a very active part; and it may be of encouragement in the future to bear in mind that one of the principal factors in determining the inclusion of Hauhangatahi within the park boundary was the fact that a former Minister, the late Hon. Dr. R. McNab, had promised a deputation of the Institute some years ago that it should be so included. It is very desirable that the Institute should obtain all information available as to existing reserves of all kinds—their status as reserves, their sanctuary value, and the dangers to which they are exposed—and that it should have a vigilant committee well versed in this information to initiate from time to time any action that may be necessary. The members of such a committee need not be members of the Board of Governors; but they should be keenly interested in the matter of reserves, and each should make a point of knowing especially the reserves of his own district and the areas that ought to be reserved.

It is a noticeable feature that, except for the Carter bequest, the Institute has received no considerable benefaction in aid of its work. The Government made for a short time a research grant by annual vote of Parliament; but this grant was one of the very first items eliminated when retrenchment became necessary. The Hector and Hutton Memorial Funds, and, lately, the Hamilton Memorial Fund, all contributed by members of the Institute, have been applied to the encouragement of research. But it cannot be said that the Institute has ever been in a position to aid and encourage research to the extent that might be expected of a body that includes practically all the scientific workers of New Zealand.

Another direction in which the Institute might be expected to take a principal part is the equipment and organizing of scientific expeditions in the Dominion and its dependencies, and, indeed, the Standing Committee recently passed a resolution recognizing the need for this work. Here, again, the lack of funds has constituted an insuperable difficulty. Scientific workers are not as a rule wealthy, or even well-to-do, and, although their private effort has never been wanting, it has been inadequate to enable the Institute to do anything like all the work that it is recognized ought to be done. Until scientific work receives the recognition that is extended to it in more enlightened countries this must always be the case. Even New Zealand began to wake up to the value of scientific work towards the end of the Great War; but it soon dropped off to sleep again.

A direction in which the Institute might, through the affiliated societies add to the usefulness of its work is in the popular exposition of scientific subjects. If the Institute were to arrange for selected members to give popular lectures in any centre that was prepared to pay the travelling-expenses of the lecturer, its readiness would, I believe, be taken advantage of, and the arousing of popular interest would be certain to have a beneficial reaction on the Institute itself.

In conclusion, I wish to thank the members of the Institute for the hearty support and co-operation they have given me during the time I have had the great honour of being President.

TRANSACTIONS.

TRANSACTIONS

OF THE

NEW ZEALAND INSTITUTE

The Uredinales, or Rust-fungi, of New Zealand: Supplement to Part 1; and Part 2.

By G. H. Cunningham, Mycologist, Biological Laboratory, Wellington, N.Z.

[*Read before the Wellington Philosophical Society, 24th October, 1922; received by Editor, 31st December, 1922; issued separately, 26th May, 1924.*]

Plates 1, 2.

SUPPLEMENT TO PART 1 OF THE UREDINALES OF NEW ZEALAND.

Additional Species of the Puccineae.

Since the first part of this paper has been sent to the press the following additional species have come to hand.

This supplement adds ten species of *Puccinia* to the New Zealand Uredinales; of these, two are introduced, one is doubtfully indigenous, and the remainder are endemic.

1. **Puccinia Elymi** Westendorp. (Fig. 77.) Gramineae.

West., *Bull. Acad. Brux.*, vol. 18, p. 408, 1851.

Aecidium Clematidis DC., *Fl. Fr.*, vol. 2, p. 243, 1805. *A. Aquilegiae* Pers., *Ic. Pict.*, p. 58, 1806. *Uredo Elymi* West., *Bull. Acad. Brux.*, vol. 18, p. 405, 1851. *Puccinia triarticulata* Berk. et Curt., *Proc. Am. Acad. Sci.*, vol. 4, p. 126, 1862. *P. tomipara* Trel., *Trans. Wis. Acad. Sci.*, vol. 6, p. 127, 1885. *P. perplexans* Plowr., *Quart. Jour. Micr. Sci.*, vol. 25, p. 164, 1885. *P. persistens* Plowr., *Brit. Ured.*, p. 180, 1889. *P. Agrostidis* Plowr., *Gard. Chron.*, ser. iii, vol. 8, p. 139, 1890. *P. Agropyri* Ell. et Ev., *Jour. Myc.*, vol. 7, p. 131, 1892. *P. Aquilegiae* Lagerh., *Tromoso Mus. Aarsh.*, vol. 17, p. 47, 1895. *P. Clematidis* Lagerh., *l.c.*, p. 54. *P. adspersa* Diet. et Holw., *Erythea*, vol. 3, p. 81, 1895. *P. triticina* Erikss., *Ann. Sci. Nat.*, ser. viii, vol. 9, p. 270, 1899. *P. agropyrina* Erikss., *l.c.*, p. 273. *P. Actaeae-Agropyri* Ed. Fisch., *Ber. Schweiz. Bot. Ges.*, vol. 11, p. 8, 1901. *P. Paniculariae* Arth., *Bul. Torr. Club*, vol. 28, p. 663, 1901. *P. Triticorum* Speg., *Anal. Mus. Nac. Buenos Aires*, ser. iii, vol. 1, p. 65, 1902. *Dicaeoma Clematidis* Arth., *Res. Sci. Congr. Bot. Vienne*, p. 344, 1906. *D. Paniculare* Arth., *l.c.* *Puccinia cinerea* Arth., *Bull. Torr. Club*, vol. 34, p. 583, 1907. *P. alternans* Arth., *Mycologia*, vol. 1, p. 248, 1909. *P. obliterata* Arth., *l.c.*, p. 250. *P. Actaeae-Elymi* Mayor, *Ann. Myc.*, vol. 9, p. 361, 1911. *Dicaeoma triticinum* Kern, *Trans. Am. Micr. Soc.*, vol. 32, p. 64, 1913. *Puccinia wyomensis* Arth., *Bull. Torr. Club*, vol. 45, p. 143, 1918. *P. missouriensis* Arth., *l.c.*, p. 146, *p.p.*

0. Spermogones epiphyllous, crowded in small groups, seated on inflated areas, immersed, honey-coloured.

I. Aecidia hypophyllous and petiolicolous, crowded in small groups up to 5 mm. diam., seated on somewhat inflated areas, orange. Peridia cylindrical, up to 2 mm. high, 0·1–0·3 mm. diam., margins slightly expanded, not revolute, white, finely laciniate. Spores globose or elliptical, 18–28 × 15–23 mmm.;* epispore hyaline, densely and minutely verruculose, 1–1·5 mmm. thick, cell-contents granular, yellow.

II. Uredosori amphigenous, scattered or crowded, seated on pallid spots, linear, 0·5–1 mm. long, orange-yellow, pulverulent, surrounded by the ruptured epidermis. Spores subglobose, elliptical or obovate, 28–32 × 23–26 mmm.; epispore hyaline, finely and closely echinulate, 1–1·5 mmm. thick, cell-contents granular, orange-yellow; germ-pores scattered, 6–8, conspicuous.

III. Teleutosori amphigenous, chiefly hypophyllous, and culmicolous, scattered or crowded, often confluent, linear, 0·5–2 mm. long, dark chestnut-brown, pulvinate, compact, long covered by the epidermis. Spores elliptic-oblong or subclavate, 40–60 × 15–20 mmm.; apex acuminate, bluntly rounded, or truncate, thickened up to 10 mmm., darker in colour, base attenuate, basal cell narrower, longer, and lighter in colour than the upper; slightly constricted at the septum; epispore smooth, chestnut-brown, 1·5–2 mmm. thick in the upper cell, 1–1·5 mmm. in the lower; pedicel persistent, hyaline, tinted beneath the spore, short, up to 15 × 6 mmm.; germ-pore of the upper cell apical, obscure, basal pore immediately beneath the septum, obscure.

X. Mesospores not uncommon, elongate-elliptical, up to 40 × 12 mmm.

Hosts:—

Deyeuxia Forsteri Kunth. On leaves and culms. Herb. No. 739. II, III. Lake Harris track, Otago, 650 m., *W. D. Reid!* 6 May, 1921.

Triticum vulgare Vill. Herb. No. 1268. Ruakura, Auckland, *A. W. Green!* 9 Jan., 1922.

Distribution: Europe; Asia Minor; Japan; North and South America; Australia.

One host is indigenous and widely spread throughout; it occurs also in Australia and Tasmania (Cheeseman, 1906, p. 868). The other is widely cultivated throughout the world.

Arthur has by a long series of cultures shown that this species consists of numerous races formerly considered to be distinct species. These so-called species were separated on account of the fact that the aecidia were known to occur on several hosts; but until the necessary cultural work had been performed by Arthur apparently no attempt had been made to ascertain whether these races were in any way associated. His arrangement of these races under the one species is followed here, and the synonymy given above taken from his paper in *North American Flora*, vol. 7, p. 333, 1920. In this paper he records fifty-nine aecidial hosts (all belonging to the family Ranunculaceae) and ninety-three telial hosts belonging to the Poaceae.

The genus *Rostrupia* Lagerh. was based on abnormal 3–4-celled forms of the teleutospores of this species.

It may be mentioned that Arthur includes here *P. agropyrina* Erikss. and *P. triticina* Erikss., two races formerly included under *P. dispersa* Erikss. et Henn. Although not sufficiently differentiated to separate as distinct species, these two forms may in the uredo stage be separated on account of the ferruginous colour of the uredosori.

* In this article the contraction "mmm." is used for "micromillimetres."

2. Puccinia Foyana n. sp.* (Fig. 78.) Ranunculaceae.

0. Unknown.

I. Aecidia amphigenous, chiefly hypophyllous, in crowded irregular groups, seated on somewhat inflated spots up to 10 mm. diam., orange. Peridia cupulate, 0·5 mm. diam., margins erect, somewhat incurved, white, laciniate. Spores polygonal or elliptical, 22–30 × 15–20 mmm.; epispore hyaline, finely and densely verruculose, 1 mmm. thick, cell-contents vacuolate, orange.

III. Teleutosori amphigenous, petiolicolous and caulicolous, arranged in scattered groups up to 5 mm. diam., bullate, pulverulent, orbicular, 0·25–0·5 mm. diam., long covered, becoming exposed by the longitudinal fissuring of the epidermis. Spores elliptical, less commonly clavate, 42–65 × 22–26 mmm.: apex acuminate, seldom rounded, crowned with a prominent hyaline papilla, slightly (6 mmm.) or not thickened, base rounded or bluntly attenuate; slightly or not constricted at the septum; epispore smooth, bright chestnut-brown, 2·5–3 mmm. thick, cell-contents granular; pedicel deciduous, hyaline, up to 30 × 8 mmm.; germ-pore of the upper cell apical, conspicuous, papillate, basal pore immediately beneath the septum, conspicuous, papillate.

X. Mesospores not uncommon, elliptical, 20–35 × 17–24 mmm.

Host: *Ranunculus Enysii* T. Kirk. On leaves, stems, and petioles. Herb. No. 581. I–III. Cass (Canterbury), 650 m., *N. R. Foy!* 20 Jan., 1922. (Type.)

The host is endemic, and is confined to the mountains of the South Island. (Cheeseman, 1906, p. 14.)

The conspicuous hyaline apical papilla, thick epispore, and large size of the teleutospores, separate this species from *P. contegens* G. H. Cunn.

3. Puccinia namua n. sp. (Text-fig. 79. and Plate 2, fig. 7.) Umbelliferae

0. Unknown.

I. Aecidia amphigenous and caulicolous, crowded in scattered groups up to 25 mm. long, seated on slightly inflated, discoloured spots, orange. Peridia cupulate, 0·25 mm. diam., 1 mm. high, margins erect, not revolute, laciniate, white. Spores polygonal or subglobose, 18–24 mmm. diam.; epispore tinted yellow, densely and minutely verruculose, 1–1·5 mmm. thick, cell-contents vacuolate, orange.

II. Uredosori amphigenous, chiefly hypophyllous, and caulicolous, on leaves scattered, orbicular, up to 1·5 mm. diam., seated on pallid-yellow spots; on stems linear, up to 3 mm. long, seldom confluent; orange-yellow, bullate, pulverulent, surrounded and partly covered by the ruptured epidermis. Spores elliptical, obovate, seldom globose, 18–30 × 16–22 mmm.; epispore tinted yellow, sparsely and moderately echinulate, 1–1·5 mmm. thick, cell-contents granular, sulphur-yellow; germ-pores 4, equatorial, obscure.

III. Teleutosori similar to the uredosori but chestnut-brown. Spores subclavate or elliptical, 30–40 × 18–26 mmm.; apex rounded, not thickened, base attenuate, lower cell narrower than the upper; slightly constricted at the septum; epispore coarsely warted, chestnut-brown, 2–2·5 mmm. thick, cell-contents granular; pedicel persistent, hyaline, fragile, up to 25 × 7 mmm.; germ-pore of the upper cell apical, conspicuous, basal pore ¾ below the septum, conspicuous.

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* Latin diagnoses of new species will be found on pages 10–13.

Host: *Anisotome filifolia* (Hook. f.) Cockayne and Laing. On leaves and stems. Herb. No. 741. I, II. Mount Isobel, Hanmer (Canterbury), 1,000 m., *W. D. Reid!* 4 Nov., 1921. I, II, III. Sugarloaf, Cass (Canterbury), 1,500 m., *W. D. Reid! N. R. Foy!* 20 Jan., 1922.

The host is endemic, and is confined to the mountains of the South Island. (Cheeseman, 1906, p. 218.)

This species is characterized by the coarsely-warted epispore of the teleutospore.

4. **Puccinia whakatipu** n. sp. (Fig. 80.)

0, I. Unknown.

II. Uredosori amphigenous, chiefly hypophyllous, and caulicolous, elliptical, 0·25–1 mm. long, scattered or crowded, bullate, pulverulent, cinnamon-brown, becoming exposed by the longitudinal fissuring of the epidermis. Spores elliptical, obovate, or subglobose, 22–35 × 18–25 mmm.; epispore pallid cinnamon, sparsely and bluntly echinulate, 2 mmm. thick, cell-contents granular, cinnamon; germ-pores 4, equatorial, obscure.

III. Teleutosori similar to the uredosori but dark chestnut-brown. Spores elliptical or subclavate, 30–40 × 20–26 mmm.; apex rounded, not thickened, base rounded, less commonly attenuate, both cells about the same size; slightly constricted at the septum; epispore minutely verruculose, chestnut-brown, 1·5 2 mmm. thick, cell-contents granular; pedicel persistent, hyaline, fragile, up to 30 × 6 mmm.; germ-pore of the upper cell apical, conspicuous, basal pore ⅓ below the septum, obscure.

Host: *Anistome filifolia* (Hook. f.) Cockayne and Laing. On leaves and stems. Herb. No. 742. II, III. Table Bay, Wakatipu (Otago), 830 m., *W. D. Reid!* 23 May, 1922. (Type.)

This species is separated from the preceding on account of the minutely-verruculose epispore of the teleutospores, sparsely-warted cinnamon-coloured epispore of the uredospores, and different sorus characters. Although both occur on the same host, they show little other than a general resemblance to each other.

5. **Puccinia Anisotominis** n. sp. (Fig. 81.)

0, I. Unknown.

II. Uredosori hypophyllous, crowded on discoloured spots, elliptical, 1–2 mm. long, bullate, pallid ferruginous, long covered. Spores subglobose, elliptical or obovate, 24 40 × 18–22 mmm.; epispore hyaline, sparsely and somewhat coarsely echinulate, 1·5–2 mmm. thick, cell-contents granular, tinted brown; germ-pores 4, equatorial, obscure.

III. Teleutosori amphigenous, chiefly hypophyllous, crowded in scattered groups, elliptical when 1–1·5 mm. long, or confluent and attaining a length of 3 mm., bullate, pulverulent, dark chestnut-brown, long covered, becoming exposed by the longitudinal fissuring of the epidermis. Spores elongate-clavate, 40–60 × 17–22 mmm.; apex bluntly acuminate, seldom rounded, thickened up to 6 mmm., base attenuate, basal cell slightly longer and narrower than the upper; constricted at the septum; epispore smooth, golden-brown, 2–2·5 mmm. thick in upper cell, 1·5–2 mmm. thick in lower, cell-contents granular; pedicel persistent, hyaline, fragile, up to 40 × 7 mmm.; germ-pore of the upper cell apical, conspicuous, basal pore immediately beneath the septum, obscure.

Host: *Anisotome Haastii* (F. v. M.) Cockayne and Laing. On leaves. Herb. No. 743. II, III. Lake Harris track, Otago, 1,000 m., *W. D. Reid!* 6 May, 1921. (Type.)

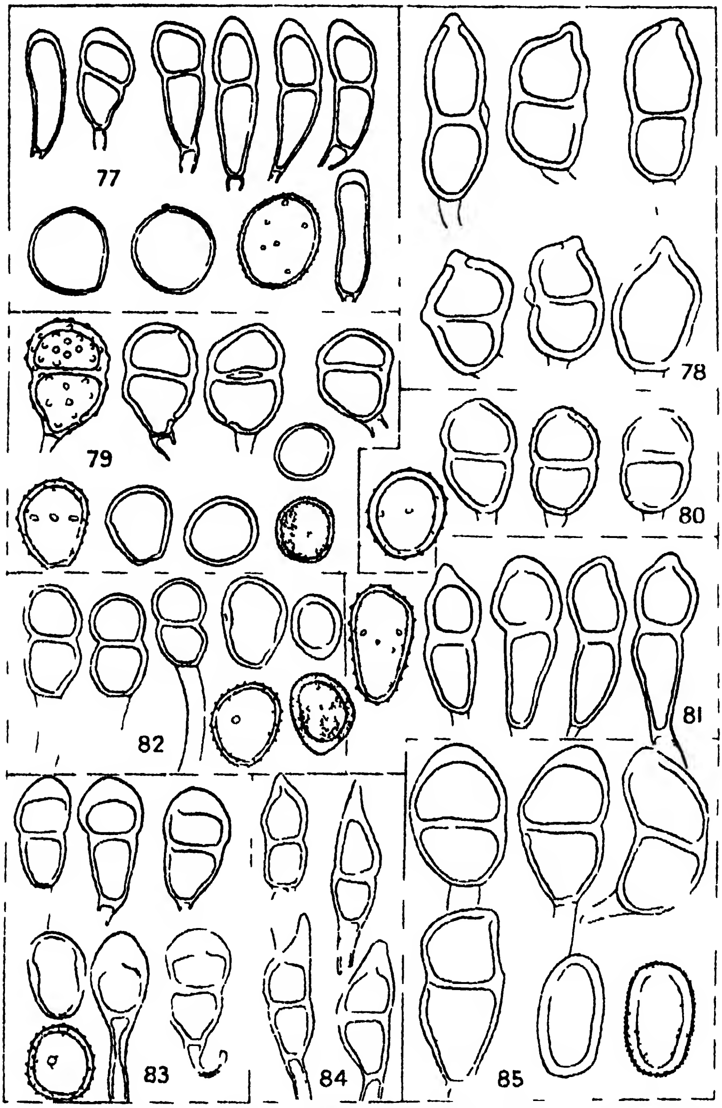


Fig. 77.—*Puccinia Elymi* West. on *Deyeuxia Forsteri* Kunth. Teleutospores, mesospores, and uredospores.

Fig. 78.—*Puccinia Foyana* G. H. Cunn. on *Ranunculus Enysii* T. Kirk. Teleutospores and mesospore.

Fig. 79.—*Puccinia namua* G. H. Cunn. on *Anisotome filifolia* (Hook. f.) Cockayne and Laing. Teleutospores, uredospores, and aecidiospores.

Fig. 80.—*Puccinia whakatipu* G. H. Cunn. on *Anisotome filifolia* (Hook. f.) Cockayne and Laing. Teleutospores and uredospore.

Fig. 81.—*Puccinia Anisotomines* G. H. Cunn. on *Anisotome Haastii* (F. v. M.) Cockayne and Laing. Teleutospores and uredospore.

Fig. 82.—*Puccinia Euphrasiana* G. H. Cunn. on *Euphrasia cuneata* Forst. Teleutospores, uredospores, and aecidiospores.

Fig. 83.—*Puccinia punctata* Link. on *Galium umbrosum* Sol. Teleutospores and uredospores.

Fig. 84.—*Puccinia Wahlenbergiae* G. H. Cunn. on *Wahlenbergia albomarginata* Hook. Teleutospores.

Fig. 85.—*Puccinia Sonchi* Rob. on *Sonchus oleraceus* L. Teleutospores and uredospores.

All figures × 400.

The host is endemic, and is confined to the South Island, where it is not uncommon in the mountain districts. (Cheeseman, 1906, p. 217.)

This rust is separated from the two preceding species on account of the differently-shaped longer teleutospores (which have a smooth epispore), and much larger coarsely-echinulate uredospores. The five species which have been recorded on the genera *Angelica* and *Anisotome* show a general family resemblance to one another, and may readily be separated by reference to the following table. The presence or absence of an aecidium is not given below as a specific character, as the cycle of those species in which it appears to be absent is at present too imperfectly known.

KEY TO SPECIES OF PUCCINIA ON ANGELICA AND ANISOTOME.

Teleutospores smooth.
  Teleutospores elongate-clavate, 40–60 × 17–2 mmm. .. .. *Anisotomes.*
  Teleutospores elliptical or subclavate, 35–45 × 21–26 mmm. .. *cuniculi.*
Teleutospores variously warted.
  Teleutospores minutely warted.
    Uredospores cinnamon, germ-spores equatorial .. .. *whakatipu.*
    Uredospores yellow; germ-pores scattered .. .. *kopoti.*
  Teleutospores coarsely warted .. .. *namua.*

6. Puccinia Euphrasiana n. sp. (Fig. 82.) Scrophulariaceae.

Uredo australis Diet. et Neg., *Engler Jahrb.*, vol. 27, p. 15, 1899.

0. Spermogones hypophyllous, immersed, sparse, scattered, associated with the aecidia.

I. Aecidia hypophyllous, in scattered groups up to 5 mm. diam., irregular, seated on discoloured spots which are absent in certain specimens, pallid-orange. Peridia depressed-globose, or angular, flattened, 0·2 mm. diam., immersed and covered by the epidermis, opening by an irregular apical pore, hyaline. Spores subglobose, polygonal or elliptical, 22–30 × 18–22 mmm; epispore hyaline, densely and minutely verruculose, 1·5 mmm thick, cell-contents vacuolate, orange.

II. Uredosori amphigenous, chiefly hypophyllous, scattered, orbicular or elliptical, 0·5–1 mm. diam., bullate, pulverulent, cinnamon-brown, surrounded by the ruptured epidermis. Spores subglobose or elliptical, 20–30 × 18–23 mmm.; epispore pallid cinnamon, moderately and finely echinulate, 1–1·5 mmm. thick, cell-contents vacuolate, cinnamon; germ-pores 2, equatorial, conspicuous.

III. Teleutosori amphigenous, in small scattered groups of 3 or 4 sori, seated on dead and discoloured spots, bullate, pulverulent, dark chestnut-brown, partially covered by the ruptured epidermis. Spores elliptical, seldom subclavate, 28–38 × 15–20 mmm.; apex rounded, not thickened; base slightly attenuate, or rounded, both cells about the same size; constricted at the septum: epispore smooth, chestnut-brown, 1·5 mmm. thick; pedicel persistent, hyaline, up to 50 × 8 mmm.; germ-pore of the upper cell apical, obscure, basal pore immediately beneath the septum, obscure.

Host: *Euphrasia cuneata* Forst. On leaves. Herb. Nos. 727, 744. I, II. York Bay, Wellington, *E. H. Atkinson!* 10 Mar., 1922. II, III. York Bay, *E. H. Atkinson! G. H. C.* 12 July, 1922; 14 Oct., 1922.

Distribution: Chile

The host is endemic, and is not uncommon in the North Island, but is sparingly distributed in the South. (Cheeseman, 1906, p. 553.)

7. Puccinia punctata Link. (Fig. 83.) **Rubiaceae.**

Link., *Ges. Nat. Freunde Berlin Mag.*, vol. 7, p. 30, 1815.

Puccinia Galii Schw., *Schr. Nat. Ges. Leipzig*, vol. 1, p. 73, 1822. *P. Galiorum* Link., in *Willd. Sp. Pl.*, vol. 6, p. 76, 1825. *Dicaeoma Galiorum* Arth., *Proc. Ind. Acad. Sci.*, 1898, p. 182, 1899. *Puccinia chondroderma* Lindr., *Medd. Stockh. Hogsk. Bot. Ins.*, vol. 4, p. 6, 1901. *Dicaeoma punctatum* (Link.) Arth., *Proc. Ind. Acad. Sci.*, 1903, p. 150, 1904.

0. Spermogones epiphyllous, sparse, in small groups, honey-coloured.

I. Aecidia hypophyllous, in small groups, or scattered, seated on pallid spots, orange-yellow. Peridia cupulate, 0·25 mm diam., margins short, erect, or somewhat recurved, finely laciniate, white. Spores globose or elliptical, 16–24 × 16–22 mmm.; epispore hyaline, densely and minutely verruculose, 1 mmm. thick, cell-contents orange-yellow.

II. Uredosori amphigenous, chiefly hypophyllous, and caulicolous, on leaves scattered, orbicular, 0·5–1 mm. diam., on stems elliptical, up to 2 mm. long, cinnamon-brown, pulverulent, surrounded by the ruptured epidermis. Spores elliptical, obovate or subglobose, 22–28 × 18–22 mmm.; epispore pallid cinnamon-brown, sparsely and moderately echinulate, 1·5 mmm. thick, cell-contents vacuolate, cinnamon; germ-pores 2, superequatorial, conspicuous.

III. Teleutosori hypophyllous and caulicolous, minute, orbicular, 0·25–1 mm. diam., chocolate-brown, pulvinate, semi-compact, surrounded by the ruptured epidermis. Spores clavate, less commonly elliptical, 35–50 × 15–22 mmm.; apex rounded, seldom acuminate, thickened up to 14 mmm.; base attenuate, lower cell narrower and lighter in colour than the upper; slightly constricted at the septum; epispore smooth, golden-brown, 2 mmm. thick in upper cell, 1·5 mmm. in lower; pedicel persistent, hyaline, tinted at the apex, up to 40 × 10 mmm.; germ-pore of the upper cell apical, conspicuous, basal pore immediately beneath the septum, obscure.

X. Mesospores common, obovate or elliptical, 25–35 mmm. long.

Hosts:

Galium umbrosum Sol. On leaves and stems. Herb. No. 745. II, III. Dunstan Mountains (Otago), 600 m., *A. H. Cockayne!* 6 Feb., 1921. II, III. Sandhills, Levin (Wellington), 16 m., *E. H. Atkinson! G. H. C.* 12 Oct., 1922.

Asperula perpusilla Hook. f. Herb. No. 746. I. Glenorchy (Otago), 400 m., *W. D. Reid!* 15 Dec., 1921. Otira Railway-station (Canterbury), *W. Martin!* 10 Feb., 1922. Ben Lomond spur (Otago), *W. D. Reid!* 31 Mar., 1921.

Distribution: Europe; Siberia; North America; Chile.

Both hosts are endemic and common throughout. Cheeseman (1906, p. 267) states that *Asperula perpusilla* would almost be better placed in *Galium*, as the corolla-tube (the only character upon which the genus is separated from *Galium*) is much shorter than is usual in this genus.

Several species are recorded as occurring on *Galium* in Europe. Of these, *P. difformis* K. et S. differs in the uredosori being absent; *P. Valantiae* Pers. in both aecidia and uredosori being absent; and *P. Celakovskyana* Bubak in the absence of aecidia. *P. Asperulae-odoratae* Wurth is separated, as it occurs on *Asperula* and is unable to infect *Galium*; morphologically it is practically identical with *P. punctata*, so that I can see no valid reason for maintaining it other than as a biological form of this latter species.

In Australia McAlpine (1906, pp. 91 and 165) records two rusts, *Uromyces Asperulae* McAlp. and *Puccinia Oliganthae* McAlp., as occurring on *Asperula.* The latter species closely resembles *P. punctata*, but differs in the more acuminate and narrower teleutospore.

In our form the aecidia differ slightly from the European in being amphigenous and caulicolous, but, as the peridial and spore characters are identical, I have thought it better to maintain all spore forms under the one name.

8. Puccinia Wahlenbergiae n. sp. (Fig. 84.) Campanulaceae.

0. Unknown.

III. Teleutosori hypophyllous, caulicolous, and on inflorescences, on leaves orbicular, 1 mm. diam., scattered, on stems linear, 1·5 mm. long compact, pulvinate, pallid brown, naked or surrounded by the ruptured epidermis. Spores fusiform or subclavate, 35–50 × 12 19 mmm.; apex strongly acuminate, thickened up to 18 mmm., base attenuate; slightly or not constricted at the septum; epispore smooth, hyaline, or tinted brown, 1·5-2 mmm. thick, cell-contents vacuolate, tinted brown; pedicel persistent, continuous with the spore, hyaline, stout, up to 30 × 10 mmm.; germ-pore of the upper cell apical, conspicuous, basal pore immediately beneath the septum, obscure.

Host: *Wahlenbergia albomarginata* Hook. On leaves, stems, and inflorescences. Herb. No. 592. III. Tokaanu–Waiouru Road, Taupo, 830 m., *E. H. Atkinson!* 12 Mar., 1922. (Type.)

The host is endemic, and is abundant in hilly and mountainous country throughout. (Cheeseman, 1906, p. 403.)

This rust is characterized by the strongly acuminate apex and persistent stout pedicels of the teleutospores.

9. Puccinia Celmisiae n. sp. (Figs. 86, 121.) Compositae.

Uredo Celmisiae Cke., *Grev.*, vol. 14, p. 89, 1886. *Uredo Compositarum* var. *Celmisiae* Cke., *Grev.*, vol. 19, p. 3, 1890.

0, I. Unknown.

II. Uredosori amphigenous, seated on discoloured spots, orbicular, 1 mm. diam., scattered, or circinnate, when circles up to 5 mm. diam., bullate, pulverulent, reddish-orange, becoming pallid yellow with age, on the lower surface deeply buried in the dense tomentum of the leaf, on the upper surface long covered by the cuticle. Spores globose or obovate, 25–40 × 23–30 mmm.; epispore hyaline, somewhat closely and finely echinulate, 1·5–2 mmm. thick, cell-contents granular, yellow; germ-pores scattered, 6–8, obscure.

III. Teleutosori similar to and arising from the same sori, chestnut-brown. Spores broadly elliptical, 50–62 × 30–36 mmm.; apex rounded, seldom acuminate, not or slightly thickened, base rounded or attenuate, both cells the same size and colour; not or slightly constricted at the septum; epispore smooth, chestnut-brown, 2–3 mmm. thick, cell-contents granular; pedicel deciduous, hyaline, fragile, 30 × 10 mmm.; germ-pore of the upper cell apical, obscure, basal pore immediately beneath or ½ way below the septum, obscure.

Hosts—

Celmisia coriacea (Forst. f.) Hook. f. On leaves. Herb. Nos. 748, 749. II, III. Mount Isobel, Hanmer (Canterbury), 1,170 m., *W. D. Reid!* 4 Nov., 1921. (Type.) II. Arthur's Pass (Canterbury), *T. Kirk!* (Type uredo material from Kew.) II. Fairfield (Dunedin), *A. W. Bathgate!* 20 June, 1921. II. Jack's Pass, Hanmer (Canterbury), 900 m., *W. D. Reid!* 12 Nov., 1921. Arthur's Pass (Canterbury), *J. G. Myers.* 1 Jan., 1923.

Celmisia Hookeri Cockayne. Herb. No. 747. II. Macraes (Otago), 600 m., *W. D. Reid!* 29 Nov., 1921.

Celmisia longifolia Cass. Herb. No. 764. II. Routeburn Valley (Otago), 800 m., *W. D. Reid!* 7 May, 1921. Lake Harris track (Otago), 1,100 m., *W. D. Reid!* 6 May, 1921. Macraes (Otago), 600 m., *W. D. Reid!* 29 Nov., 1921. Taupo-Tokaanu Road, Taupo, 450 m., *E. H. Atkinson!* 6 Mar., 1922

Celmisia longifolia Cass. var. *alpina* T. Kirk. II. Walter Peak (Otago), 400 m., *W. D. Reid!* 27 April, 1921.

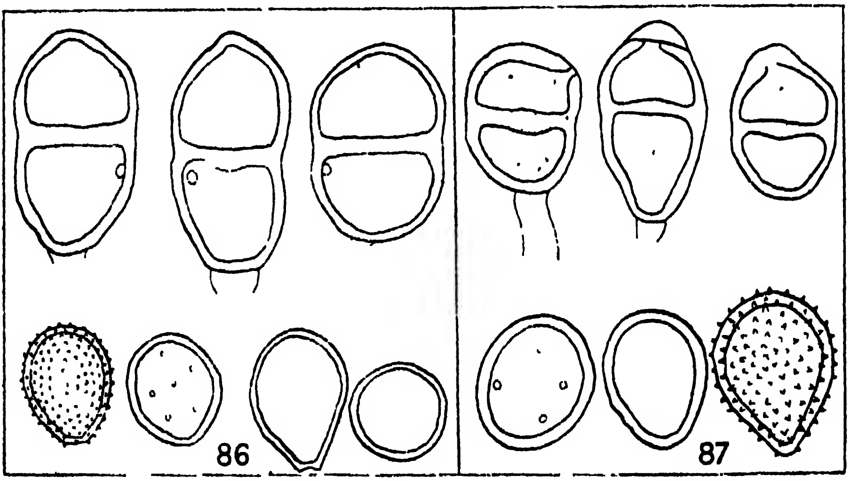


FIG. 86.—*Puccinia Celmisiae* G. H. Cunn. on *Celmisia coriacea* (Forst. f.) Hook. f. Teleutospores and uredospores. × 500.
FIG. 87.—*Puccinia fodiens* G. H. Cunn. on *Celmisia rigida* Cockayne. Teleutospore and uredospores. × 500.

All hosts with the exception of *Celmisia longifolia* Cass. are endemic; the latter species occurs also in Australia and Tasmania (Cheeseman, 1906, pp. 310–314.)

One other rust found on *Celmisia* in New Zealand, *P. fodiens* G. H. Cunn. (fig. 87), closely resembles the species described above, but differs in several particulars. The main differences are tabulated below, and in the text the two illustrations are placed together so that the differences may be observed the more readily.

P. fodiens:—

Uredospores—

Epispore sparsely and coarsely echinulate, 3 mmm. thick.

Teleutospores—

40–55 × 28–35 mmm.; apex acuminate, thickened up to 10 mmm., epispore finely punctate.

P. Celmisiae:—
Uredospores—
Epispore fairly closely and finely echinulate, epispore 1·5–2 mmm. thick
Teleutospores –
50–62 × 30–36 mmm.; apex rounded, not or slightly thickened, epispore smooth.

10. **Puccinia Sonchi** Roberge. (Fig. 85.)

Rob., in Desm., *Ann. Sci. Nat.*, ser. iii, vol. ii, p. 74, 1849.

Gymnoconia Cirsii-lanceolati Bubak, *Konigl. Boehm. Gesfar. Wiss. Mathem-naturwiss Classe*, p. 10, 1899.

0. Spermogones amphigenous, scattered, sparse, associated with the uredosori.

II. Uredosori amphigenous and caulicolous, scattered, or more commonly in small orbicular or elliptical groups of 3–5 sori, 1 3 mm. long, seated on discoloured spots, orbicular, 0·25–1 mm. diam., on stems elliptical, confluent, and up to 5 mm. long, bullate, immersed, partly covered by the epidermis, yellow, opening by an irregular apical pore, encircled by a single layer of thick-walled chestnut-brown paraphyses. Spores elliptical or obovate, 30–42 × 20–24 mmm.; epispore hyaline, densely and finely verrucose, 3–4 mmm. thick, cell-contents yellowish, oily; germ-pores indistinct.

III. Teleutosori hypophyllous, scattered or confluent, seated on discoloured spots, bullate, dark chestnut-brown, orbicular or irregular, up to 2 mm. diam., compact, long covered by the epidermis; encircled by a single layer of chestnut-brown clavate paraphyses. Spores elliptical or subclavate, 50–60 × 24–31 mmm.; apex rounded or bluntly acuminate, thickened up to 6 mmm., base attenuate, frequently rounded, lower cell slightly narrower; not or slightly constricted at the septum; epispore smooth, pallid chestnut-brown, 1·5 2 mmm. thick, cell-contents granular; pedicel persistent, tinted brown, up to 38 × 8 mmm.; germ-pore of the upper cell apical or slightly oblique, conspicuous, basal pore immediately beneath the septum, conspicuous.

X. Mesospores not uncommon, subclavate or obovate, up to 53 mmm. long.

Host: *Sonchus oleraceus* L. On leaves and stems. Herb. No 281.
II, III. Palmerston North (Wellington), 300 m., *G. H. C.* 14 June, 1919.

Distribution: Western Europe; Algeria; Canaries; Japan; Ceylon.

The host is introduced.

Grove (1913, p. 156) states that the paraphyses of the uredosori are in reality the upper part of an imperfect peridium; at the top these cells become elongated and parallel, they are at first hyaline, but finally become dark brown and irregular in shape. This peculiar feature, and the immersed character, has led systematists to confuse it with an aecidium, but, as the uredospores are borne singly on pedicels, no such confusion should arise. In the specimens at hand a few teleutospores are present in the uredosori.

LATIN DIAGNOSES.

1. **Puccinia Foyana** sp. nov. (Fig. 78.) Ranunculaceae.

0. Incognitis.

I. Aecidiis amphigeniis, praecipue hypophyllis, in catervis irregularibus congestis, ad 10 mm. latis, luteis. Peridiis cupulatis, 0·5 mm. latis, marginibus erectis, aliquantum incurvis, albis, laciniatis. Aecidiosporis polygoniis vel ellipticis, 22–30 × 15–20 mmm.; episporio hyalino, dense minuteque verrucoso, 1 mmm. crasso, contentu vacuolato, luteo.

III. Soris teleutosporiferis amphigeniis, petiolicoliis, et caulicolis, in catervis congestis, ad 5 mm. latis, bullatis, pulverulentibus, rotundis, ad 0·25–0·5 mm. latis, diu tectis ad extremum expositis rupta epidermide. Teleutosporis ellipticis, raro obovatis, 42–65 × 22–26 mmm.; apice acuminato, raro rotundato, papillato, leniter (6 mmm.) vel non incrassato, basi rotundato, non saepe attenuato, leniter ad septum constricto, episporio leve, castaneo, 2·5–3 mmm. crasso, contentu granuloso; pedicello deciduo, hyalino, ad 30 × 8 mmm.; foramine germinis cellulae superioris apicale, conspicuo, foramine basali etatim infra septum, conspicuo, saepe papillato.

X. Mesosporis vulgaribus, ellipticis, 20–35 × 17–24 mmm.

Habitat: In foliis vivis, petiolibusque et caulisque *Ranunculi Enysii* T. Kirk. Cass, Canterbury, New Zealand. *N. R. Foy.*

2. **Puccinia namua** sp. nov. (Fig. 79.) Umbelliferae.

0. Incognitis.

I. Aecidiis amphigeniis et caulicolis, in catervis congestis, ad 25 mm. longis, in maculis decoloratis inflatis, luteis. Peridiis cupulatis, 0·25 mm. latis, 1 mm. exstitis, marginibus erectis, non revolutis, laciniatis, albis. Aecidiosporis polygoniis vel subglobosis, 18–24 mmm. latis; episporio pallido-flavo, dense minuteque verrucoso, 1–1·5 mmm. crasso, contentu vacuolato, luteo.

II. Uredosoris amphigeniis, praecipue hypophyllis, et caulicolis, in foliis raris, rotundis, ad 1·5 mm. latis, in maculis pallido-flavis, in caulibusque ellipticis, ad 3 mm. longis, raro confluentibus, luteis, bullatis, pulverulentibus, rupta epidermide cinctis et partim tectis. Uredosporis ellipticis, obovatis, raro globosis, 18–30 × 16–22 mmm.; episporio pallido-flavo, raro et leniter echinulato, 1–1·5 mmm. crasso, contentu granuloso, luteo.

III. Soris teleutosporiferis uredosoris immixis et similibus, castaneis. Teleutosporis subclavatis vel ellipticis, 30–40 × 18–26 mmm.; apice rotundato, non incrassato, basi attenuato; ad septum leniter constricto: episporio rustice verrucoso, castaneo, 2–2·5 mmm. crasso, contentu granuloso; pedicello persistente, hyalino, delicato, ad 25 × 7 mmm; foramine germinis cellulae superioris apicale, conspicuo, foramine basali $\frac{3}{4}$ infra septum, conspicuo.

Hab.: In foliis vivis et caulisque *Anisotomenis filifoliae* (Hook. f.) Cockayne et Laing. Mount Isobel, Hanmer, Canterbury, New Zealand. *W. D. Reid.*

3. **Puccinia whakatipu** sp. nov. (Fig. 80.)

0, I. Incognitis.

II. Uredosoris amphigeniis, praecipue hypophyllis et caulicolis, ellipticis, ad 0·25–1 mm. longis, raris vel catervis, bullatis, pulverulentibus, cinnamomeis, diu tectis ad extremum expositis rupta epidermide. Uredosporis ellipticis, obovatis vel subglobosis, 22–35 × 18–25 mmm.; episporio pallido-cinnamomeo, raro rustice echinulato, 2 mmm. crasso, contentu granuloso, cinnamomeo; foraminibus germinis 4, circulis, obscuris.

III. Soris teleutosporiferis uredosoris similibus, castaneo-fuscis. Teleutosporis ellipticis vel subclavatis, 30–40 × 20–26 mmm.; apice rotundato, non incrassato, basi rotundato raro attenuato; ad septum leniter constrictis; episporio subtiliter verruculoso, castaneo, 1·5–2 mmm. crasso, contentu granuloso; pedicello persistente, hyalino, delicato, ad 30 × 6 mmm.;

foramine germinis cellulae superioris apicale, conspicuo, foramine basali ½ infra septum, obscuro.

Hab.: In foliis vivis *Anisotominis filifoliae* (Hook. f.) Cockayne et Laing. Table Bay, Wakatipu, Otago, New Zealand. *W. D. Reid.*

4. **Puccinia Anisotominis** sp. nov. (Fig. 81.)

0, I. Incognitis.

II. Uredosoris hypophyllis, in maculis catervis, ellipticis, ad 1–2 mm. latis, bullatis, pallido-ferrugineis, tectis. Uredosporis subglobosis, ellipticis vel obovatis, 24–40 × 18–22 mmm.; episporio hyalino, raro rusticeque echinulato, 1·5–2 mmm. crasso, contentu granuloso, fuscus, foraminibus germinis 4, circulis, obscuris.

III. Soris teleutosporiferis amphigenis, praecipuo hypophyllis, confertis, ellipticis ad 1 1·5 mm. longis, vel confluentibus, ad 3 mm. longis; bullatis, pulverulentibus, fusco-castaneis, diu tectis ad extremum expositis rupta epidermide. Teleutosporis elongato-clavatis, 40–60 × 17 22 mmm.; apice rustice acuminato, raro rotundatis ad 6 mmm. crasso, basi attenuato; ad septum constrictis; episporio leve, aureo-fusco, 2· 2·5 mmm. crasso in cellulo superiore, 1–1·5 mmm. in cellulo inferiore, contentu granuloso; pedicello persistente, hyalino, delicato, ad 40 × 7 mmm.; foramine germinis cellulae superioris apicale, conspicuo, foramine basali etatim infra septum, obscuro.

Hab.: In foliis vivis *Anisotominis Haastii* (F. v. M.) Cockayne et Laing. Lake Harris track, Otago, New Zealand. *W. D. Reid.*

5. **Puccinia Euphrasiana** sp. nov. (Fig. 82.) Scrophulariaceae.

Uredo australis Diet. et Neg., *Engler Jahrb.*, vol. 27, p. 15, 1899.

0. Spermagoniis hypophyllis, immersis, sparsis, raris, aliquantum aecidiis immixis.

I. Aecidiis hypophyllis, in raris catervis ad 5 mm. latis, in maculis decolatis, luteo. Peridiis plano-globosis, vel irregularibus, ad 0·2 mm. latis, diu epidermide tectis, hyalinis. Aecidiosporis subglobosis, polygoniis vel ellipticis, 22–30 × 18–22 mmm.; episporio hyalino, dense minuteque verruculoso, 1·5 mmm. crasso, contentu vacuolato, luteo.

II. Uredosoris amphigeniis, praecipue hypophyllis, raris, rotundatis vel ellipticis, ad 0·5–1 mm. latis, bullatis, pulverulentibus, cinnamomeis, epidermide rupta cinctis. Uredosporis subglobosis vel ellipticis, 20–30 × 18–23 mmm.; episporio pallido-cinnamomeo, leniter et aliquantum minute echinulato, 1–1·5 mmm. crasso, contentu vacuolato, cinnamomeo; foraminibus germinis 2, circulis, conspicuis.

III. Soris teleutosporiferis amphigeniis, in raris catervis 3–4 soriis, in maculis decoloratis, bullatis, pulverulentibus, fusco-castaneis, rupta epidermide cinctis et partim tectis. Teleutosporis ellipticis vel subclavatis, 23–38 × 15–20 mmm.; apice rotundato, non incrassato, basi leniter attenuato vel rotundato; ad septum constrictis; episporio leve, castaneo, 1·5 mmm. crasso; pedicello persistente, hyalino, ad 50 × 8 mmm; foramine germinis cellulae superioris apicale, obscuro, foramine basali etatim infra septum, obscuro.

Hab.: In foliis vivis *Euphrasiae cuneatae* Forst. York Bay, Wellington, New Zealand. *E. H. Atkinson, G. H. C.*

6. Puccinia Wahlenbergiae sp. nov. (Fig. 84.) Campanulaceae.

0. Incognitis.

III. Soris teleutosporiferis hypophyllis, caulicolis et floricolis, in foliis rotundis, raris, ad 1 mm. latis, in caulibusque ellipticis, ad 1·5 mm. longis, compactis, pulvinatis, pallido-fuscis, nudis vel epidermide rupta cinctis. Teleutosporis fusiformis vel subclavatis, 35–50 × 12·19 mmm.; apice fortis acuminato, ad crasso 18 mmm., basi attenuato; ad septum leniter necne constrictis; episporio leve, hyalino, vel pallido-fusco, 1·5–2 mmm. crasso, contentu vacuolato, pallido-fusco; pedicello persistente, hyalino, crasso, ad 30 × 10 mmm.; foramine germinis cellulae superioris apicale, conspicuo, foramine basali etatim infra septum, obscuro.

Hab.: In foliis vivis et caulibusque *Wahlenbergia albomarginata* Hook. Tokaanu -Waiouru Road, Taupo, New Zealand. *E. H. Atkinson.*

7. Puccinia Celmisiae sp. nov. (Fig. 86.) Compositae.

0, I. Incognitis.

II. Uredosoris amphigeniis, in maculis discoloratis, rotundatis, raris, ad 1 mm. latis vel circinnatis ad 5 mm. latis, bullatis, pulverulentibus, luteis, in denso tomento folii profundo immersis. Uredosporis globosis vel obovatis, 25–40 × 23–30 mmm.; episporio hyalino, minute tenuiter echinulato, 2 mmm. crasso, contentu granuloso, luteo; foraminibus germinis raris, 6–8, obscuro.

III. Soris teleutosporiferis uredosoris similibus, castaneis. Teleutosporis late ellipticis, 50·62 × 30–36 mmm.; apice rotundato, non incrassato, basi rotundato vel attenuatis, ad septum necne leniter constricto; episporio leve, pallido-castaneo, 2–3 mmm. crasso, contentu granuloso; pedicello deciduo, hyalino, delicato, ad 30 × 10 mmm.; foramine germinis cellulae superioris apicale, obscuro, foramine basali etatim infra vel ½ infra septum, obscuro.

Hab.: In foliis vivis *Celmisiae coriaceae* (Forst. f.) Hook. f. et *Celmisiae Hookeri* Cockayne. Mount Isobel, Hanmer, Canterbury, New Zealand. *W. D. Reid.*

THE UREDINALES, OR RUST-FUNGI, OF NEW ZEALAND: PART 2.

1. Family MELAMPSORACEAE.
2. Family COLEOSPORIACEAE.
3. Family PUCCINIACEAE (*continuatio*), Tribe PHRAGMIDEAE.
4. Family UREDINALES IMPERFECTI.
5. APPENDIX: Fungi parasitic upon the Uredinales.

The present paper is a continuation of Part 1, published in the *Transactions of the New Zealand Institute*, vol. 54, pp. 619–704, and deals with the remaining species of the New Zealand Uredinales at present in the herbarium (Cryptogams) of the Biological Laboratory. In this paper thirty-five species are dealt with, these belonging to three families and seven genera; but the greater number are but form-species included under the form-genera *Aecidium* and *Uredo*. This by no means completes the record of the New Zealand Uredinales, as fresh collections, often containing undescribed species, are constantly being sent in to the Laboratory. Doubtless within a few years the number of species will be doubled. The life-history of

members of each family differs somewhat from that of *Puccinia* as given in Part 1, p. 620; the differences are discussed under the descriptions of the families concerned.

Again I wish to record thanks to the following: W. D. Reid, E. H. Atkinson, and E. Bruce Levy, of the Biological Laboratory, for contributions of specimens; Dr. W. B. Grove (University of Birmingham), Dr. J. R. Weir (Bureau of Mycological Exchange, Washington), and Mrs. F. W. Patterson (late of the Bureau of Mycological Exchange, Washington), for contributions of specimens for comparative purposes; Dr. E. J. Butler (Director, Bureau of Mycology, Kew) and Mr. E. W. Mason (of the Imperial Bureau), for assistance regarding literature and references; Mr. C. C. Brittlebank (Department of Agriculture, Melbourne), for material for comparative purposes, loan of many type specimens, and for literature references; and Mr. J. G. Myers, for the revision of all Latin diagnoses.

The following publications have proved very useful, particularly in giving the geographical range of species, genera, and families; I have drawn freely from the synonymy cited in these works, this having been made necessary owing to the scarcity in New Zealand of most of the earlier literature: *The British Rust Fungi* (W. B. Grove); *North American Flora*, vol. 7 (J. C. Arthur): *The Rusts of Australia* (D. McAlpine); *Sylloge Fungorum* (P. A. Saccardo); *Thesaurus* (Lindau and Sydow); *Manual of the New Zealand Flora* (T. F. Cheeseman).

All drawings were made with the aid of a camera lucida, from spores mounted in 50 per cent. lactic acid-water solution. Drawings are all to the same scale, unless otherwise specified, and have all been reduced the same amount. Surface-sculpturings have been studied from material mounted dry, as in many instances the markings are not visible when spores are mounted in the usual solutions. It is frequently difficult to determine the number and position of the germ-pores, owing to the contents rendering the cell opaque. Generally, boiling for a second or so in lactic acid is all that is necessary to render the pores visible; frequently, however, it is necessary to treat the spores specially with certain stains (*e.g.*, Bismarck brown, eosin, or many other of the anilins will suffice), but in certain refractory cases no treatment will render the pores visible, when they are, in this paper, given as being "indistinct."

III. PUCCINIACEAE (*continuatio*).

Teleutosori compacted or pulverulent, naked or covered by the epidermis. Teleutospores one- to many-celled, free, borne on distinct pedicels; epispore coloured or hyaline, smooth, or variously sculptured, with one or more germ-pores in each cell. Basidia external.

Tribe PHRAGMIDEAE.

Teleutospores in pulvinate, dark-coloured sori	5. *Phragmidium*.
Teleutospores in yellow fibrils	6. *Hamaspora*.

5. PHRAGMIDIUM Link.

Link., *Ges. Nat. Freunde Berlin Mag.*, vol. 7, p. 30, 1815.

Hypodermium Link., *l.c.*, p. 26. *Aregma* Fr., *Obs. Myc.*, vol. 1, p. 225, 1815. *Epitea* Fr., *Syst. Myc.*, vol. 3, p. 510, 1832. *Lecythea* Lev., *Ann. Sci. Nat.*, ser. iii, vol. 8, p. 373, 1847. *Earlea* Arth., *Res. Sci. Congr. Bot. Vienne*, p. 341, 1906.

Autoecious. Cycle of development includes 0, I, II, III.

0. Spermogones conical or flattened, subcuticular, without ostiolar filaments.

I. Caeomata indefinite, erumpent, without peridia but usually encircled by paraphyses. Caematospores catenulate usually subglobose, epispore hyaline or tinted yellow, verrucose; germ-pores scattered, numerous, obscure.

II. Uredosori without peridia, usually encircled by paraphyses, erumpent, pulverulent. Uredospores globose or elliptical, borne singly on pedicels; epispore verrucose or echinulate, coloured or hyaline; germ-pores scattered, numerous, obscure.

III. Teleutosori erumpent, definite, with or without paraphyses, soon naked, almost black. Teleutospores divided by transverse septa into 2 or several cells; wall laminate, the middle layer dark-coloured and rigid, usually coarsely warted, sometimes smooth; germ-pores 2 to several in each cell, laterally placed, conspicuous; pedicels prominent, persistent, hyaline, often roughened and much swollen below. Basidiospores subglobose, smooth.

This genus is confined to the host family Rosaceae.

Distribution: Europe; Asia; North and South America; Ceylon; Australia.

Of the five New Zealand species, three are endemic, one is indigenous, and one introduced.

On germination a basidium is produced from each cell of the teleutospore; this becomes four-celled, and from each cell arises a sterigma, bearing on its apex the subglobose basidiospore.

Phragmidium is a well-defined genus, and is characterized by the large, many-celled, dark-coloured teleutospores; the wall of the spore is thick, usually opaque, and distinctly laminated. This feature may readily be seen if the spores are boiled for a second or two in lactic-acid solution, for the epispore becomes much swollen and may be seen as a hyaline envelope surrounding the spore, often swelling to a thickness of 10 mmm. or more.

The apex is usually crowned with a conspicuous hyaline or coloured papilla, but in certain species this may be wanting. The pedicels often attain a length several times that of the spore; they are hyaline, persistent, stout, and frequently the lower part is swollen, the central area of this swollen portion being often stuffed with an oily coloured matrix, a feature seen as a rule only in fresh material.

The caeomata greatly resemble the uredosori, and are sometimes difficult to separate on account of this similarity, but the catenulate spores characterize them.

KEY TO THE SPECIES OF PHRAGMIDIUM.

Host belonging to the family Rosaceae.
  Host belonging to the tribe Roseae .. .. 1. *Phr. mucronatum.*
  Host belonging to the tribe Potentilleae.
    Teleutospores 1–6-celled, commonly 4–5 .. 4. *Phr. Potentillae.*
    Teleutospores 4–7-celled, commonly 6.
      Teleutospores long-cylindrical .. .. 2. *Phr. Acaenae.*
      Teleutospores oblong-terete .. .. 5. *Phr. subsimile.*
    Teleutospores 5–8-celled, commonly 7–8 .. .. 3. *Phr. novae-zelandiae.*

1. **Phragmidium mucronatum** Schlechtendal. (Fig. 88.) Rosaceae.

Schlecht. *Fl. Berol.*, vol. 2, p. 156, 1824.

Uredo Rosae-centrifoliae Pers., *Syn. Fung.*, p. 215, 1801. *U. miniata* Pers., *l.c.*, p. 216. *U. elevata* Schum., *Enum. Pl. Saell.*, vol. 2, p. 229, 1803. *U. Rosae* Schum., *l.c.*, p. 230. *Puccinia Rosae* Schum., *l.c.*, p. 235. *Aecidium Rosae* Roehling, *Deuts. Fl.*, 2nd ed., vol. 3, p. 122, 1813. *Aregma mucronata* Fr., *Obs. Myc.*, vol. 1, p. 225, 1815. *Uredo Eglanteriae* H. Mart., *Fl. Mosq.*, 2nd ed., p. 230, 1817. *Caeoma miniatum* Schlecht., *Fl. Berol.*, vol. 2, p. 120, 1824. *C. Rosae* Schlecht., *l.c.* *Phr. oblongum* Bon., *Coniom.*, p. 60, 1860. *Phr. Rosarum* Fcl., *Symb. Myc.*, p. 47, 1869. *Phr. subcorticinum* Wint., in *Rabh. Krypt. Fl.*, vol. 1, p. 228, 1881. *Phr. disciflorum* James, *Contr. U.S. Nat. Herb.*, vol. 3, p. 276, 1895. *Aregma disciflora* Arth., *Proc. Ind. Acad. Sci.*, 1898, p. 179, 1899. *Phragmidium Rosae-pimpinellifoliae* Diet., *Hedw.*, vol. 44, p. 339, 1905.

0. Spermogones caulicolous, sparse, flattened, immersed, honey-coloured.

I. Caeomata hypophyllous, caulicolous, petiolicolous and fructicolous, on leaves scattered or crowded, orbicular, pulvinate, 0·25–1 mm. diam., on stems confluent, up to 20 mm. long, forming large inflated distortions; reddish-orange, pulverulent; paraphyses present and as a rule encircling only the smaller sori; incurved, clavate, hyaline. Spores elliptical, obovate, or subglobose, 22 30 × 15–23 mmm.; epispore hyaline, finely and densely verruculose, 2–2·5 mmm. thick, cell-contents oily, reddish-orange.

II. Uredosori hypophyllous, scattered, seated on pallid-yellow spots, orbicular, 0·25–0·5 mm. diam., orange, pulverulent; encircled by a layer of incurved hyaline, clavate paraphyses. Spores elliptical, obovate, or subglobose, 22–28 × 15–20 mmm.; epispore hyaline, closely, finely and bluntly echinulate, 2 mmm. thick, cell-contents pallid-orange; germ-pores scattered, numerous (6–8), obscure.

III. Teleutosori hypophyllous, scattered, orbicular, 0·25–0·5 mm. diam., somewhat pulverulent, black, naked, with numerous spores in each sorus. Spores 5–9-celled, commonly 7 8, oblong-terete, 72–98 × 28–35 mmm.; apex obtusely rounded, not thickened, crowned with a prominent papilla, hyaline at the tip, coloured below, not continuous with the upper cell-wall, up to 12 mmm. long, base rounded or truncate, spore narrowed slightly above and below; not constricted at the septa; wall dark chestnut-brown, opaque, 5–7 mmm. thick, unevenly covered with coarse hyaline warts which are more numerous apically; pedicel persistent, continuous with the spore, tinted above, hyaline below, hollow, up to 150 mmm. long, 8–10 mmm. thick, slightly (15 mmm.) swollen at the base, lower third minutely and closely verruculose, central area filled with an oily orange-coloured matrix; germ-pores 3–5 in each cell, commonly 3, conspicuous.

Hosts:—

Rosa Eglentaria Mill. (= *R. rubiginosa* L.). On leaves, stems, petioles, and fruits. Herb. No. 373. I. York Bay (Wellington), *E. H. Atkinson!* 3 April, 1921. Blenheim, *E. H. Atkinson!* 3 Nov., 1922. Mapua (Nelson), *G. H. C.* 17 May, 1922.

Rosa sp. cult. II, III. Nelson, *W. C. Hyde!* 7 Jan., 1922.

Distribution: Europe; western Asia; North and South America; Hawaii; Ceylon; Australia.

Both hosts are introduced, the former being common throughout. The caeomata form conspicuous reddish-orange inflated areas on the stems of sweetbrier. The mycelium of this stage is perennial in the host-tissues, so that once the plant has become infected the rust appears on it season

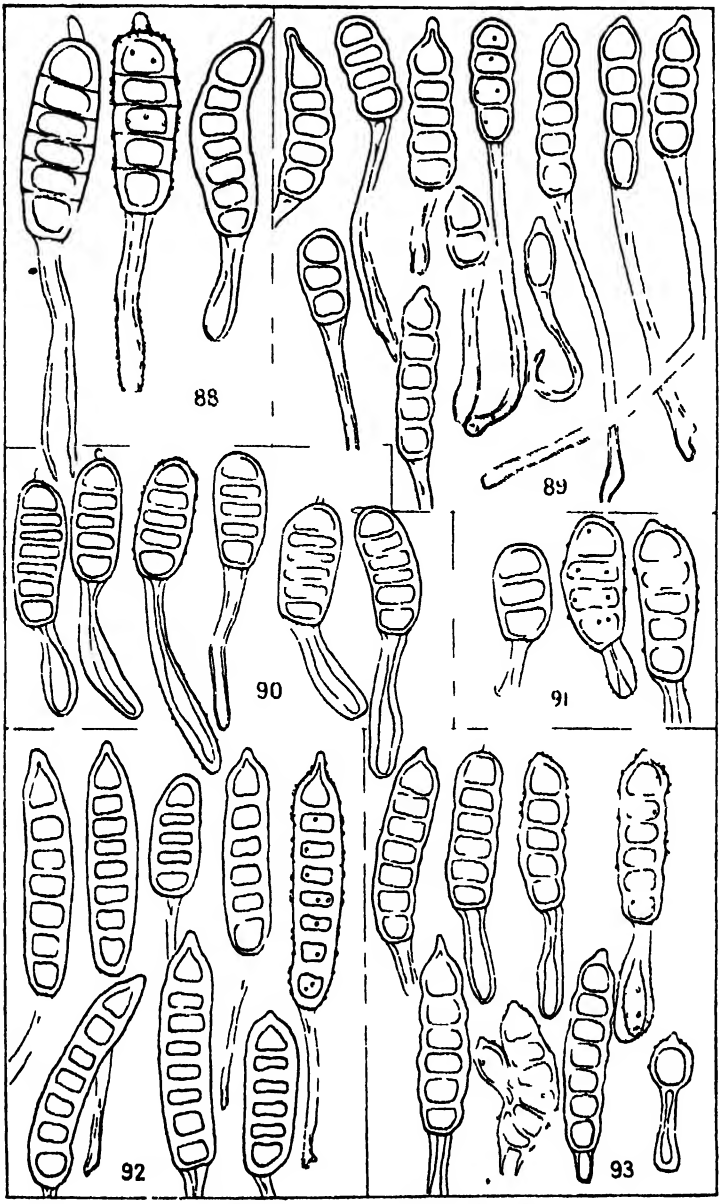


FIG 88 - *Phragmidium mucronatum* Schlecht Teleutospores from *Rosa* sp cult

FIG. 89.—*Phragmidium Potentillae* P. Karst. Teleutospores from *Acaena Sanguisorbae* Vahl.

FIG. 90. *Phragmidium subsimile* G. H. Cunn. Teleutospores from *Acaena Sanguisorbae* Vahl. var. *pilosa* T. Kirk.

FIG. 91.—*Phragmidium Sanguisorbae* Schroet. Teleutospores from *Poterium Sanguisorba.* Material collected by Dr. Grove, Boxhill, London, 29th August, 1920.

FIG. 92.—*Phragmidium novae-zelandiae* G. H. Cunn. Teleutospores from *Acaena novae-zelandiae* T Kirk.

FIG. 93.—*Phragmidium Acaenae* G. H. Cunn. Teleutospores from *Acaena microphylla* Hook. f.

All × 300.

after season. Spores so produced cause local infection of the leaves, and these sori in turn give rise to uredo- and teleuto-spores.

This rust is prevalent throughout the Nelson and Marlborough districts, and in the spring becomes conspicuous on account of the brilliant colour of the caeomatospores.

Ramsbottom (1913) has shown that the name of this species should be as above.

2. **Phragmidium Acaenae** n. sp.* (Text-fig. 93, and Plate 1, fig. 1.)

0. Spermogones amphigenous, sparse, scattered, conical, pallid yellow.

I. Caeomata hypophyllous, scattered, orbicular when 0·5 1 mm. diam., or elliptical and up to 3 mm. long, pulvinate, pulverulent, orange; encircled by a dense layer of hyaline, incurved, clavate, persistent paraphyses, overtopping the spores. Spores globose, obovate, or less commonly elliptical, 18 28 × 16–20 mmm.; epispore hyaline, closely and finely verruculose, 1–1·5 mmm. thick, cell-contents orange, vacuolate.

III. Teleutosori hypophyllous and petiolicolous, sparse, scattered, orbicular, 0·1–0·5 mm. diam., at first compact and pulvinate, becoming pulverulent, shining-black, naked, with few spores in each sorus. Spores 4–7-celled, commonly 6, long-cylindrical, 50–95 × 20 25 mmm.; apex bluntly acuminate or rounded, slightly or not thickened, often crowned with a prominent hyaline papilla, up to 10 mmm. long, not continuous with the upper cell-wall, base rounded, spore slightly or not narrowed above and below; not or slightly constricted at the septa: wall light chestnut-brown, 3-4 mm. thick, sparsely covered with a few coarse hyaline warts which are more numerous apically or may be almost absent; pedicel persistent, continuous with the spore, tinted above, hyaline below, hollow, up to 50 mmm. long, commonly much less, 5–9 mmm. thick, swollen at the base to 20 mmm., lower third closely verruculose, germ-pores 2-3 in each cell, conspicuous.

Host: *Acaena microphylla* Hook. f. On leaves and petioles. Herb. No. 307. I, III. Botanical Gardens, Gore (Southland), *E. B. Levy!* 1 Feb., 1921. (Type.)

The host is endemic, and is not uncommon throughout the mountain districts. (Cheeseman, 1906, p. 132.)

This species closely resembles *Phr. subsimile*, but differs in the long-cylindrical shape of the teleutospores, their verrucose apex, much shorter pedicels, and in the cells not being discoid.

3. **Phragmidium novae-zelandiae** n. sp. (Text-fig. 92, and Plate 1, fig. 2.)

0. Spermogones similar to *Phr. Acaenae*.

I. Caeomata similar to *Phr. Acaenae*.

III. Teleutosori hypophyllous, sparse, elliptical, up to 3 mm. long, pulvinate, pulverulent, the spores becoming agglutinated into compact masses, dull greyish-black, naked, with very many spores in each sorus. Spores 4–8-celled, commonly 6–7, oblong-cylindrical, 65–118 × 18-24 mmm.; apex acuminate, seldom rounded, not or slightly thickened, drawn into a long papilla, continuous with the upper cell-wall, tinted, hyaline at the

* Latin diagnoses of new species will be found on pages 51–55.

tip, up to 8 mmm. long, base rounded or slightly attenuate, spore slightly narrowed above and below; not constricted at the septa; wall sepia-coloured, 4 6 mmm. thick, coarsely and densely warted, warts hyaline and more numerous apically; pedicel persistent, continuous with the spore, hyaline below, tinted above, up to 100 mmm. long, 4 6 mmm thick, not or slightly inflated basally, lower half minutely and densely verruculose, germ-pores 2 4 in each cell, conspicuous.

Host: *Acaena novae-zelandiae* T. Kirk. On leaves. Herb No. 766. I-III. Seashore, Seatoun (Wellington), *E. H. Atkinson! G. H. C.* 27 Jan., 1921. Queenstown (Otago), 400 m., *W. D. Reid!* 18 Dec., 1921. (Type.)

The host is endemic and is not uncommon throughout. (Cheeseman, 1906, p. 131.)

This rust is characterized by the large size of the teleutospores, large number of cells, dark and thick wall, and acuminate apex. The pedicels are more slender than in our other species, and are not swollen at the base. The large number of teleutospores in the sorus, and the manner in which they are compacted together, serve to separate this from any other species that may be present on the same plant.

4. **Phragmidium Potentillae** P. Karsten. (Text-fig. 89, and Plate 1, fig. 3.)

Karst., *Bidr. Finl. Nat. Folk*, vol. 31, p. 49, 1879.

Puccinia Potentillae Pers., *Syn. Fung.*, p. 229, 1801. *Uredo Potentillae* Schum., *Enum. Pl. Saell.*, vol. 2, p. 228, 1803. *Phragmidium obtusatum* Schmidt and Kunze, *Deuts. Schwamme*, vol. 5, p. 5, 1816. *Caeoma Potentillae* Schlecht., *Fl. Berol.*, vol. 2, p. 121, 1824.

0. Spermogones amphigenous, in small scattered groups, pallid yellow.

I. Caeomata amphigenous, solitary or crowded, often confluent, elliptical, less commonly orbicular, 0·5 1·5 mm. long, pulverulent, orange; encircled by a dense layer of cylindrical, hyaline, incurved paraphyses. Spores subglobose or elliptical, 20–26 × 15–22 mmm.; epispore hyaline, finely and closely verrucose, 1·5 2 mmm. thick, cell-contents orange.

II. Uredosori hypophyllous, scattered, orbicular, 0·5–2 mm. diam., pulverulent, orange, encircled by a layer of cylindrical or clavate hyaline, incurved paraphyses. Spores subglobose or obovate, 18–26 × 15–20 mmm.; epispore hyaline, finely and closely echinulate, 1·5 mmm. thick, cell-contents orange; germ-pores scattered, numerous, obscure.

III. Teleutosori amphigenous, chiefly hypophyllous, scattered or confluent, orbicular, 0·25-3 mm. diam., pulvinate, compact, shining-black, naked, with numerous spores in each sorus. Spores 1 5-celled, commonly 4, cylindrical, 55-95 × 18–25 mmm.; apex acuminate or rounded, not thickened nor papillate, base rounded; constricted at the septa; wall golden-brown, smooth, 2–4 mmm. thick; pedicel persistent, continuous with the spore, very long, up to 200 mmm. by 4–7 mmm. thick, hyaline, hollow, not or slightly swollen at the base, lower third closely and finely verruculose; germ-pores 2–3 in each cell, conspicuous.

Hosts:—

Acaena Sanguisorbae Vahl. On leaves. Herb. Nos. 75, 765, 770. I. Karori (Wellington), 100 m., *G. H. C.* 5 Mar., 1920. III. Routeburn Valley (Otago), 500 m, *W. D. Reid!* 8 May, 1921. II, III. Table Bay, Wakatipu (Otago), 850 m., *W. D. Reid!* 23 May, 1922.

Acaena novae-zelandiae var. *pallida* T. Kirk. Herb. No. 296. II. Seashore, Seatoun (Wellington), *E. H. Atkinson! G. H. C.* 27 Jan., 1921.

Acaena ovina A. Cunn. Herb. No. 296. II. Seashore, Seatoun (Wellington), *E. H. Atkinson! G. H. C.* 27 Jan., 1921.

Distribution: Europe; Asia Minor; Siberia; Japan; North America; Australia.

Two of the hosts are indigenous, *A. novae-zelandiae* var. *pallida* being endemic; *A. ovina* has been introduced from Australia. (Cheeseman, 1906, p. 131, 1073.)

The New Zealand form does not agree in all particulars with the European, differing mainly in the acuminate apex of the teleutospore. The cylindrical shape of the teleutospore, smooth, light-coloured wall, constrictions at the septa, and very long slender pedicels, separate this from other species found in New Zealand on *Acaena*. Specimens vary somewhat in the degree of roundness or otherwise of the apex, as well as in the length of the pedicels, for in certain sori the spores may all be rounded at the apex, and in others they all may be acuminate; the pedicels may average 100 mmm. in length, or may be twice this length. Generally, the larger the sorus the longer the pedicels.

Teleutospores are abundant in New Zealand, and in some collections literally cover the leaves of the host. As they may frequently be found on the same plant with *Phr. subsimile*, and occasionally even on the same leaf, the following method of separating the two on sorus characters may prove useful:—

Teleutosori compact, shining-black, usually small	..	*Phr. Potentillae.*
Teleutosori pulverulent, greyish-black, usually large	..	*Phr. subsimile.*

It is difficult to separate caeomata from uredosori, as they generally closely resemble one another; frequently sections are necessary to determine the difference. In this species, however, the uredosori are generally surrounded by the ruptured epidermis, which persists for a considerable time; this feature is generally absent from the caeomata, or, if not absent, is invariably less noticeable.

5. **Phragmidum subsimile** n. sp. (Fig. 90.)

0. Spermogones hypophyllous, sparse, scattered, pallid yellow.

I. Caeomata hypophyllous, sparse, scattered, orbicular, 0·5–3 mm. diam., pulverulent, orange; encircled by a dense layer of hyaline, clavate, incurved, persistent paraphyses. Spores subglobose, 18–22 mmm.; epispore hyaline, densely and closely verrucose, 1·5 2 mmm. thick, cell-contents vacuolate, orange.

III. Teleutosori hypophyllous, scattered, elliptical, up to 2 mm. long, pulverulent, greyish-black, containing very many spores in each sorus. Spores 5-7-celled, commonly 6, oblong-terete, 57–70 × 22–30 mmm.; apex rounded, not thickened, often crowned with a prominent, tinted, smooth papilla, not continuous with the upper cell-wall, up to 10 mmm. long, base rounded, spore markedly narrowed above and below; not constricted at the septa; wall chestnut-brown, 3–5 mmm. thick, sparsely and coarsely warted, warts hyaline, unequally distributed; pedicel persistent, continuous with the spore, tinted above, hyaline below, stout, up to 100 mmm. long, 6–10 mmm. thick, hollow, swollen to 18 mmm. at base, lower half closely and minutely verruculose; germ-pores 2–3 in each cell, obscure.

Hosts :—

Acaena Sanguisorbae Vahl. var. *pilosa* T. Kirk. On leaves. Herb. Nos. 443, 767, 768. I, III. Macraes (Otago) 600 m., *W. D. Reid!* 28 Nov., 1921. Queenstown (Otago), 650 m., *W. D. Reid!* 18 Dec., 1921. (Type.)

Acaena Sanquisorbae Vahl. Herb. No. 769. I, III. Table Bay, Wakatipu (Otago), 850 m., *W. D. Reid!* 23 May, 1922.

The host species *A. Sanguisorbae* is indigenous and widespread; it occurs also in Australia, Tasmania, and Tristan d'Acunha; the variety *pilosa* is endemic, and is not uncommon. (Cheeseman, 1906, p. 131.)

This species somewhat resembles *Phr. Sanguisorbae* Schroet. (fig. 91), but differs in the differently-shaped, broader teleutospores, in there being 5–7 cells in the spore instead of 2–5, and in the much longer pedicels. The teleutosorus characters, too, are quite different.

This species serves as a connecting-link between *Phr. Acaenae* and *Phr. Sanguisorbae;* and, of the New Zealand species, one would imagine the ancestral form to have been of the *Phr. Sanguisorbae* type, from which arose in succession *Phr. subsimile*, *Phr. Acaenae*, and finally *Phr. novae-zelandiae*. *Phr. Potentillae*, on the other hand, would appear to have arisen from a different form, as it has not the same general resemblance to the three species discussed above. Dr. Cockayne informs me that the hosts readily hybridize, and that the so-called species *A. Sanguisorbae* is in reality a composite species. This would partly account for the fact that on this species as many as three species of *Phragmidium* occur, whereas on other well-defined host species, and even varieties, one rust only is found.

I am indebted to Dr. Grove for specimens of *Phr. Sanguisorbae*, from which fig. 91 has been drawn.

6. HAMASPORA Koernicke.

Koern., *Hedw.*, vol. 16, p. 23, 1877.

Autoecious. Cycle of development includes 0, II, III.

0. Spermogones scattered, flattened-globose, subcuticular, associated with the uredosori.

II. Uredosori without peridia, definite, erumpent, encircled by a dense layer of hyaline incurved paraphyses. Uredospores borne singly on pedicels, globose or obovate; epispore hyaline, thick, verruculose; germ-pores scattered, numerous, obscure.

III. Teleutosori erumpent, definite, paraphysate, orange. Teleutospores aggregated into conspicuous fibrillose filaments, consisting of spores and pedicels closely interwoven; 4-6-celled by transverse septa; wall not distinctly laminate, hyaline, smooth, with one indistinct germ-pore in each cell; pedicels several times the length of the spore, hyaline; basidiospores obovate or reniform, smooth.

Distribution: Africa; Philippines; Java; Australia.

The single New Zealand species is indigenous and widespread. The genus is confined to *Rubus*, a genus of the family Rosaceae.

Hamaspora consists of two species—*H. longissima* (Theum.) Koern., found in South Africa on *Rubus rigida*, and *H. acutissima* Syd., occurring on *Rubus Rolfei* in the Philippines, and on *R. moluccanus* L. in Java and Queensland.

In the past confusion has arisen as to the systematic position of this species, and many systematists have placed it under *Phragmidium*, but

that it is not a *Phragmidium* becomes obvious when the following facts are considered :—

(*a*.) Sorus characters: The teleutospores are early aggregated into fibrillose filaments; in mass they are pallid yellow (cream or white with age), not dark coloured.

(*b*.) The uredosori are accompanied by the spermogones, caeomata being absent.

(*c*.) The shape of the teleutospore does not resemble any species of *Phragmidium*, although approaching certain species of *Gymnosporangium*.

(*d*.) The hyaline non-laminate wall of the teleutospore differs from any species of *Phragmidium*, but approaches *Gymnosporangium*.

(*e*.) The presence of a solitary germ-pore in each cell is a character not present in any *Phragmidium*, and occurs in only a few species of *Gymnosporangium*. Moreover, with these two genera the pores are usually conspicuous, whereas with *Hamaspora* the pores are visible only at germination.

(*f*.) The method of germination differs slightly from *Phragmidium*, but considerably from that of *Gymnosporangium*.

(*g*.) The pedicels are of an extraordinary length, and taper gradually to a fine point.

From a consideration of these facts it would appear that, morphologically, the teleutospores more closely resemble *Gymnosporangium* than they do *Phragmidium*, and that in behaviour towards their hosts (*e.g.*, being autoecious instead of heteroecious) and in the method of germination they more closely approach *Phragmidium*.

1. **Hamaspora acutissima** Sydow. (Text-figs. 94, 95, and Plate 1, fig. 4.) Rosaceae.

Syd., *Mon. Ured.*, vol. 3, p. 80, 1912.

0. Spermogones immersed, hypophyllous, associated with the uredosori.

II. Uredosori hypophyllous, scattered, orbicular, 0·25–0·5 mm. diam., golden-yellow; surrounded by and mixed with numerous incurved hyaline cylindrical paraphyses. Spores globose, obovate, or shortly elliptical, 20–25 × 17–19 mmm.; epispore hyaline, finely and densely verruculose, 2 mmm. thick, thickened at the apex to 3·5 mmm., cell-contents pallid yellow; germ-pores scattered, 6–8, obscure.

III. Teleutosori hypophyllous, scattered or crowded in irregular groups, seated on indefinite pallid spots which are visible on the upper surface, elliptical, 0·5–1 mm. diam., pulverulent, surrounded by the ruptured epidermis. Spores aggregated into pallid-yellow fibrils up to 20 mm. long, fading with age, 4–6-celled, long-cylindrical, 100–180 × 14–22 mmm.; apex strongly acuminate, tapering to a fine sharp point, thickened up to 10 mmm., base truncate; not constricted at the septa; epispore hyaline, smooth, 1 mmm. thick, cell-contents orange, granular; pedicel persistent, continuous with the spore, tapering basally to a fine point, up to 600 mmm. long, 10–15 mmm. thick immediately below the spore, hollow; germ-pore solitary in each cell, indistinct.

Host: *Rubus australis* Forst. f. On leaves. Herb. Nos. 7, 594. III. Herekopere Islands, *T. Kirk!* 1882. Mount Waiopehu (Wellington), 1,000 m., *G. H. C.* 26 Oct., 1919. Otira Gorge (Canterbury), 500 m., *E. H. Atkinson!* 30 Jan., 1920. Peel Forest (Canterbury), 250 m.,

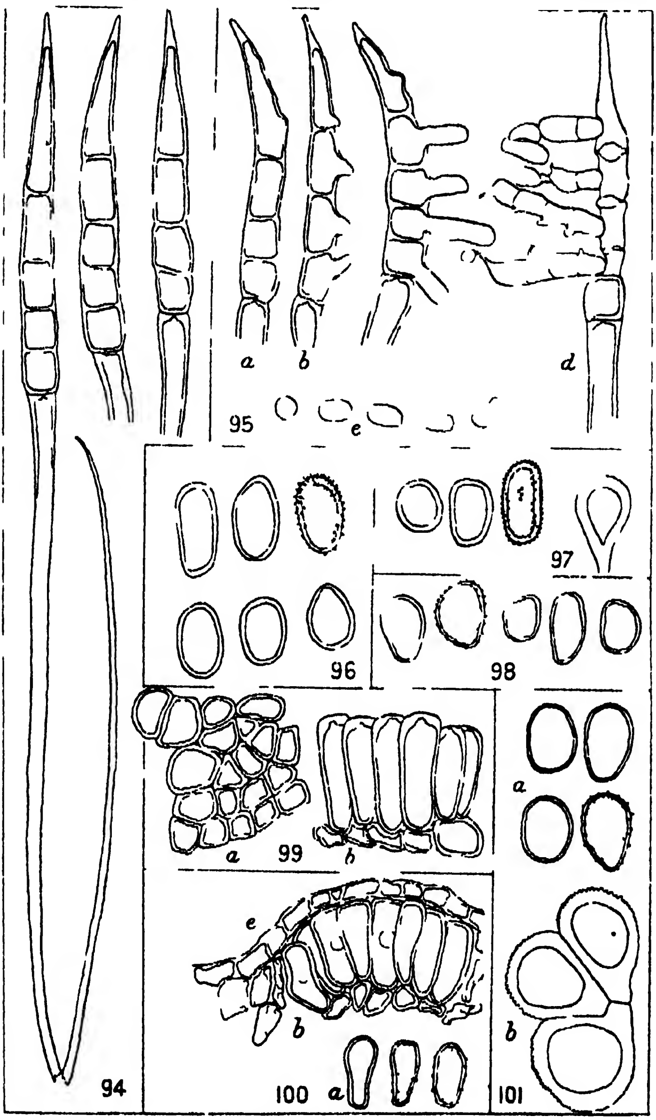


FIG. 94.—*Hamaspora acutissima* Syd. Teleutospores from *Rubus australis* Forst f.
FIG. 95 —*Hamaspora acutissima* Syd Teleutospores, showing different stages during germination, (*e*) basidiospores, one germinating
FIG. 96.—*Coleosporium Fuchsiae* Cke. Uredospores from *Fuchsia excorticata* (Forst f) L. f.
FIG. 97.—*Melampsora Kusanoi* Diet. Uredospores and paraphysis from *Hypericum gramineum* Forst. f.
FIG. 98 - *Pucciniastrum pustulatum* Diet Uredospores from *Epilobium pubens* A. Rich.
FIG. 99.—*Melampsora Lini* Desmaz. Teleutospores from *Linum monogynum* Forst. (*a*) Plan of same showing arrangement of the spores in a sorus, larger cells on the outside. Note germ-pores
FIG. 100.—*Melampsoridium betulinum* Kleb. Uredo and teleuto-spores from *Betula alba* L. (*a*) Uredospores, (*b*) teleutospores covered by epidermis (*e*) Note fusion nucleus in several of the cells
FIG. 101.—*Milesina Histiopteridis* G. H. Cunn Uredospores and peridial cells (*b*) from *Histiopteris incisa* (Thunb.) J. Sm.

Figs. 94 and 95 × 300; all others × 400

H. H. Allan! Feb., 1920. Makarora (Otago), *W. D. Reid!* 25 Mar., 1921. Tokaanu Waiouru Road, Taupo, 400 m., *E. H. Atkinson!* 11 Mar., 1922.

Distribution: Java; Queensland.

The host is endemic, and is common throughout. (Cheeseman, 1906, p. 125.) The teleutospore stage only has been collected in New Zealand; this is common, and is readily observed owing to the conspicuous nature of the spore-masses.

The description of the uredospores given above is drawn up from information kindly supplied by Mr. C. C. Brittlebank, Melbourne.

The spores and their pedicels are inextricably interwoven into filaments, so that it is difficult to separate out single spores for the purposes of measurement and drawing. These filaments are formed in the following manner: The sori are at first bullate and covered by the epidermis; this soon becomes ruptured, owing to the increasing pressure exerted by the developing spores, and the spores become exposed, when they are seen as a pulvinate mass standing above the leaf-surface about 0·5 mm. Spores are being produced from the same sorus during the whole of the summer months, and appear to be developed in batches. As each successive batch develops, the spores become forced between the pedicels of the preceding batch, which are consequently carried upward away from the base of the sorus. Gradually the filament becomes formed, and, as the spores and pedicels of successive batches are closely interwoven, the filament does not break up, but remains compact, and may persist for several seasons, especially if it happens to become entangled with the spines which cover the under-surface of the leaf. The filaments do not, as a rule, remain for any length of time attached to the sori, so that they may frequently be seen on the same leaf with the detached filaments. The empty sorus usually contains numerous incurved, cylindrical paraphyses. Germination occurs as soon as the spores mature, and, as spores of all ages usually occur in the same filament, different stages of development may readily be obtained. The first indication of germination is the appearance of a slight swelling on one side of a cell; this is followed by the gradual development of the basidium, which protrudes at this point. At first unicellular, the basidium soon becomes four-celled by the appearance of transverse septa. Shortly after the septa appear the sterigmata grow out, one from each cell of the basidium; on each a small, smooth-walled, colourless basidiospore appears. The basidia are allantoid, and may attain a size of 60 × 10 mmm.; the basidiospores are obovate or reniform, and usually 15 × 10 mmm.

Until 1912, when P. and H. Sydow (*l.c.*) separated the species described above, one species only was known. This was by Thuemen in 1875 (*Flora*, vol. 58, p. 379) described as *Phragmidium longissimum.* Two years later Koernicke (*l.c.*) placed it in *Hamaspora*, a genus he erected to contain it and another form with similar spores (now *Gymnosporangium Ellisii* Farl.). In 1888 De Toni (in Sacc., *Syll.*, vol. 7, p. 750) compiled it under *Phragmidium.* Massee in 1893 (*Grev.*, vol. 22, p. 17) considered that it was neither *Hamaspora* nor *Phragmidium*, but stated that he did not care to undertake the responsibility of forming a new genus (!). Dietel (1900, p. 73) considered that there were no grounds for separating it from *Phragmidium*, although he recognized a resemblance to *Gymnosporangium* in the teleutospore structure. McAlpine (1906, p. 187) in 1906 included it under *Phragmidium*, but mentioned the fact that it differed considerably from other species included in that genus.

II. COLEOSPORIACEAE.

Teleutosori waxy. Teleutospores compacted laterally into one (seldom two) waxy layer, sessile. Basidia internal. Uredosori, when present, naked (*Coleosporium*), or encircled by paraphyses (*Ochropsora*); uredospores catenulate (*Coleosporium*), or borne singly on pedicels (*Ochropsora*). Aecidia, when present, with a definite peridium; spores catenulate.

The contents of the teleutospores at maturity become divided into four cells by transverse septa; from each cell grows out a sterigma bearing the basidiospore. This internal basidium characterizes the family, which contains the following five genera, only one of which has been collected in New Zealand: (1) *Coleosporium* Lev.; (2) *Gallowaya* Arth.; (3) *Ochropsora* Diet.; (4) *Chrysopsora* Lagerh.; and (5) ? *Zaghouania* Pat. *Chrysopsora* is by Dietel (1900) included in the Pucciniaceae, but the internal basidium excludes it from this family. *Zaghouania* has the basidium formed internally, but prior to the formation of the basidiospores the basidium becomes external. On this account it has been placed in a separate family, the Zaghouaniaceae, by Dumee and Maire (*Bull. Soc. Myc. Fr.*, 1902). Grove (1913, p. 318) provisionally places it in the Coleosporiaceae.

1. COLEOSPORIUM (Leveille).

Lev., *Ann. Sci. Nat.* ser. 3, vol. 8, p. 373, 1847.

Peridermium Chev., *Fl. Env. Paris*, vol. 1, p. 385, 1826. *Erannium* Bon. *Conom.*, p. 17, 1860. *Stichopsora* Diet., *Bot. Jahrb.*, vol. 27, p. 565, 1899.

Heteroecious. Cycle of development includes 0, I, II, III.

0. Spermogones flattened, linear, without ostiolar filaments, dehiscing by a logitudinal fissure.

I. Aecidia erumpent, definite. Peridia cylindrical, inflated, opening by an irregularly torn apical cleft, hyaline. Aecidiospores subglobose or elliptical; epispore hyaline, covered with densely-packed deciduous tubercules; germ-pores absent.

II. Uredosori without peridia, erumpent, definite, pulverulent. Uredospores catenulate, subglobose, elliptical, or obovate; epispore hyaline, verruculose, tubercules somewhat deciduous; germ-pores indistinct.

III. Teleutosori indehiscent, waxy, flattened, indefinite. Teleutospores at first unicellular, becoming 4-celled by transverse septa, sessile; epispore smooth, hyaline, strongly thickened at the apex; germ-pores indistinct.

Distribution: Europe; America; Asia; East Indies. The following endemic species occurs in New Zealand.

Aecidia, where known, occur on the needles of two-leaved species of *Pinus*; the other stages on several families of dicotyledons. In *Gallowaya*, on the other hand, the teleutospores (the only stage known) occur on *Pinus*, and on account of this fact, and because only teleutospores are known in the cycle, Arthur (1906, p. 336) placed it in a separate genus.

1. Coleosporium Fuchsiae Cooke. (Text-fig. 96, and Plate 2, fig. 9.)

Onagraceae.

Cke., *Grev.*, vol. 14, p. 129, 1886.

0, I. Unknown.

II. Uredosori amphigenous, seated on small angular yellow spots, orbicular, 0·5–1 mm. diam., orange-yellow, pulverulent, pulvinate, surrounded by the ruptured epidermis. Spores elliptical, obovate, or subglobose, 20–31 × 14–18 mmm; epispore hyaline, closely, coarsely and unequally

echinulate, spines sparsely distributed towards base of spore, 1·5 mmm. thick, cell-contents granular, orange; germ-pores indistinct.

III. Unknown.

Host: *Fuchsia excorticata* (Forst. f.) L. f. On leaves. Herb. Nos. 190, 620. II. Hawyard's, Upper Hutt (Wellington), *T. Kirk!* 3 Sept., 1881. (Type collection.) Weraroa (Wellington), *G. H. C.* 6 Oct., 1919. (On seedlings.) York Bay (Wellington), *E. H. Atkinson!* 24 Oct., 1920. Palmerston North (Wellington), *R. Waters!* 27 Jan., 1921. Seashore, Seatoun (Wellington), *E. H. Atkinson! G. H. C.* 24 March, 1922. Oamaru (Otago), *R. B. Tennent!* 27 May, 1921. Claudelands, Hamilton, *G. H. C.* 24 May, 1922.

The host is endemic, and is abundant throughout. (Cheeseman, 1906, p. 186.)

This rust is common in certain parts of New Zealand, and is conspicuous owing to the bright orange colour of the uredosori; in certain specimens the entire leaf-surface may be covered with the sori.

The uredo stage alone is known; the uredospores do not closely resemble other species of the genus, differing particularly in being echinulate and not covered with deciduous tubercules.

I. MELAMPSORACEAE.

Teleutosori waxy. Teleutospores sessile, compacted laterally into a flat crust, seldom solitary within the host-tissues, unicellular, or divided longitudinally into 2–4 cells. Basidium external. Uredosori with or without peridia; uredospores borne singly on pedicels. Aecidia with or without peridia.

On germination a basidium is produced from the apex of the spore; this becomes four-celled by transverse septa, and from each cell there arises a sterigma, bearing the basidiospore on its apex. This method of germination, together with the waxy compacted teleutosori, characterize the family.

Nine genera are by Grove (1913, p. 336) included in the family. Arthur (1907) places it, together with the Cronartiaceae, in one family which he has termed the Uredinaceae, including in all eighteen genera. Dietel (1900) includes both the Cronartiaceae and Coleosporiaceae under the Melampsoraceae, including in all fourteen genera.

The following four genera occur in New Zealand:

Key to the Genera of Melampsoraceae.

Uredosori enclosed in peridia, opening by an apical pore.
 Sori on Filicales .. .. 4. *Milesina.*
 Sori on Phanerogams.
  Teleutospores unicellular, united into lateral flat waxy crusts .. .. 2. *Melampsoridium.*
  Teleutospores 2–4-celled by vertical septa .. .. 3. *Pucciniastrum.*
Uredosori naked, or surrounded only by paraphyses .. .. 1. *Melampsora.*

1. Melampsora Castagne.

Cast., *Obs. Myc.*, vol. 2, p. 18, 1843.

Physonema Lev., *Ann. Sci. Nat.*. ser. 3, vol. 8, p. 374, 1847. *Podosporium* Lev., *l.c.* *Podocystis* Fr., *Summa Veg. Scand.*, vol. 2, p. 512, 1849. *Caeoma* Tul., *Ann. Sci. Nat.*, ser. 4, vol. 2, p. 172, 1854. *Uredo* Pers., ex Arth., *N. Am. Fl.*, vol. 7, p. 97, 1907. *Bubakia* Arth., *Res. Sci. Congr. Bot. Vienne*, p. 338, 1906.

Autoecious and heteroecious. Cycle of development includes 0, I, II, III.

0. Spermogones hemisphaerical, flattened, without ostiolar filaments.

I. Caeomata erumpent, without peridia or paraphyses, pulvinate. Caeomatospores globose; catenulate: epispore hyaline, finely verruculose; germ-pores scattered, obscure.

II. Uredosori without peridia, pulverulent, erumpent. Uredospores borne singly on pedicels, intermixed with capitate paraphyses; epispore hyaline, verrucose; germ-pores equatorial or scattered, obscure.

III. Teleutosori indehiscent. Teleutospores compacted laterally into flat waxy irregular dark-coloured layers, unicellular, prismatic or elliptical; epispore coloured, smooth; germ-pore apical, obscure.

Distribution: World-wide. Two indigenous species occur in New Zealand.

The teleutospores form conspicuous chestnut-brown waxy crusts, often 15 mm. long, on the stems and leaves of the hosts. They are closely compacted together, and in consequence appear prismatic in shape.

1. **Melampsora Kusanoi** Dietel. Guttiferae.

Diet., Engl., *Bot. Jahrb.*, vol. 37, p. 104, 1905.

0. Unknown.

II. Uredosori amphigenous, chiefly hypophyllous, scattered, pulverulent, elliptical, 0·2–0·5 mm. long, reddish-orange when fresh, yellowing with age, surrounded by the ruptured epidermis mixed with numerous hyaline capitate paraphyses. Spores subglobose or elliptical, 17–24 × 12–17 mmm.; epispore hyaline, closely and coarsely verruculose, 1·5–2 mmm. thick; germ-pores scattered, 3–4, obscure.

III. Teleutosori hypophyllous, scattered or aggregated in small irregular groups, subepidermal, minute, 0·3–0·5 mm. diam., at first chestnut-brown, becoming black. Spores prismatic, 22–32 × 6–12 mm.; apex rounded or truncate, slightly (2–3 mmm.) thickened; epispore smooth, yellowish, 1 mm. thick: germ-pore apical, obscure.

Host: *Hypericum gramineum* Forst. f. On leaves. Herb. No. 279. II. Alexandra (Otago), 600 m., *G. H. C.* 10 Dec., 1919.

Distribution: Japan; Australia.

The host is indigenous, and is fairly widely distributed; it occurs also in Australia, Tasmania, and New Caledonia. (Cheeseman, 1906, p. 74.)

Only the uredospores have been collected in New Zealand, but both stages have been recorded from Australia by McAlpine (1906, p. 191) as *M. Hypericorum* Schroet.

Sydow has suggested (*Mon. Ured.*, vol. 3, p. 386, 1912) that *Aecidium disseminatum* Berk. is probably the uredo stage of this species; but McAlpine (1906, p. 200) had specimens of an *Aecidium* on *Hypericum japonicum* compared with the type of *Aec. disseminatum* at Kew, when they were found to be identical.

2. **Melampsora Lini** Desmazieres. (Text-fig. 99, and Plate 1, fig. 6.) Linaceae.

Desm., *Pl. Crypt.*, fasc. 41, No. 2049, 1850.

Uredo Lini Schum., *Enum. Pl. Saell.*, vol. 2, p. 230, 1803. *Podosporium Lini* Lev., *Ann. Sci. Nat.*, ser. 3, vol. 8, p. 374, 1847. *Podocystis Lini* Fr., *Summa Veg. Scand.*, p. 512, 1849. *Melampsora liniperda* Koern., *Centralbl. f. Bakter*, vol. 32, p. 278, 1911.

0. Spermogones amphigenous, numerous, scattered, immersed, inconspicuous.

I. Caeomata amphigenous, chiefly hypophyllous, scattered, orbicular, 0·2–0·5 mm. diam., orange, pulverulent, surrounded by the ruptured epidermis. Spores subglobose, 20–28 mmm. diam.; epispore hyaline, finely and closely verruculose, 1 mmm. thick, cell-contents vacuolate, yellow.

II. Uredosori amphigenous and caulicolous, scattered or crowded, orbicular, 0·5 mm. diam., on stems elliptical and up to 2 mm. long, pulvinate, pulverulent, surrounded by the ruptured epidermis; mixed with numerous incurved, hyaline, capitate paraphyses. Spores subglobose, obovate or broadly elliptical, 18–24 × 14–18 mmm.; epispore hyaline, closely and finely verruculose, 2 mmm. thick; germ-pores equatorial, obscure.

III. Teleutosori amphigenous and caulicolous, scattered or crowded, often confluent and up to 8 mm. long, irregular, discoid, reddish-brown, becoming shining-black, long covered. Spores laterally compacted, subepidermal, prismatic, unicellular, 40–55 × 9–15 mmm.; apex obtusely rounded or truncate, slightly (3 mmm.) or not thickened, base truncate; epispore smooth, brown, 1 mmm. thick; germ-pore obscure, apical.

Hosts:

Linum monogynum Forst. On leaves and stems. Herb. Nos. 241, 297. II. York Bay (Wellington), *E. H. Atkinson!* 24 Oct., 1920. II, III. Seashore, Seatoun (Wellington), *E. H. Atkinson!* 27 Jan., 1921.

Linum monogynum Forst. var. *chathamicum* Cockayne. II. York Bay (Wellington), *E. H. Atkinson!* 23 Jan., 1921.

Distribution: Europe; North and South America; Australia.

Both hosts are endemic; they are especially abundant along the sea-coasts. (Cheeseman, 1906, p. 86.)

The uredosori are common, and are conspicuous owing to their bright orange colour. The teleutosori appear to be rare here, as only a few sori have been found on the abundant material in hand.

2. Melampsoridium Klebahn.

Kleb., *Zeits. Pflanzenkr.*, vol. 9, p. 21, 1899.

Heteroecious. Cycle of development includes 0, I, II, III.

0. Spermogones globose, flattened, without ostiolar filaments.

I. Aecidia with a well-developed peridium, inflated, cylindrical, erumpent. Aecidiospores globose or elliptical, epispore hyaline, minutely and densely verruculose, thin.

II. Uredosori immersed, enclosed within a definite peridium, opening by an apical pore. Uredospores borne singly on pedicels, elliptical, paraphyses absent; epispore hyaline, echinulate; germ-pores indistinct.

III. Teleutosori indehiscent, subepidermal. Teleutospores compacted laterally into flattened layers, unicellular, elliptical or prismatic; epispore coloured, smooth; germ-pore apical, obscure.

Distribution: Europe; Asia; North America. The solitary New Zealand species has been introduced.

This genus is separated from *Melampsora* on account of the presence of a definite peridium surrounding the aecidio- and uredo-spores, and from *Pucciniastrum* on account of the teleutospores being laterally compacted into waxy layers. It would thus appear to be an intermediate genus, the I and II stages linking it with *Pucciniastrum*, and the teleutospores with *Melampsora*.

1. **Melampsoridium betulinum** Klebahn. (Fig. 100.) Betulaceae.

Kleb., *l.c.*, p. 21.

Uredo Betulae Schum., *Enum. Pl. Saell.*, vol. 2, p. 228, 1803. *Melampsora betulina* Tul., *Ann. Sci. Nat.*, ser. 4, vol. 2, p. 97, 1854. *Aecidium Laricis* Kleb., *Zeits. Pflanzenkr.*, vol. 9, p. 18, 1899. *Peridermium Laricis* Arth. et Kern, *Bull. Torr. Club*, vol. 33, p. 436, 1906. *Melampsoridium Betulae* Arth., *N. Am. Fl.*, vol. 7, p. 110, 1907.

0. Spermogones amphigenous, numerous, scattered, flattened, inconspicuous.

I. Aecidia hypophyllous, solitary, or in rows parallel to the midrib, reddish-orange. Peridia elliptical, up to 1 mm. high, 1 mm. long, margin irregularly torn, tinted. Spores subglobose or elliptical, 16–25 × 12–16 mmm.; epispore hyaline, minutely and closely verruculose, 1–1·5 mmm. thick, slightly thinner and more smooth on one side.

II. Uredosori hypophyllous, immersed, scattered, orbicular, 0·1 mm. diam. Peridia flattened-globose, dehiscing by an apical pore. Spores elliptical or subclavate, 20–35 × 10–15 mmm.; epispore hyaline, sparsely and somewhat coarsely echinulate, smooth towards the apex, 1 mmm. thick; germ-pores indistinct.

III. Teleutosori hypophyllous, immersed, scattered, orbicular, 0·5 mm. diam., chestnut-brown, indehiscent. Spores compacted into a flattened crust, prismatic, 35–45 × 10–15 mmm.; apex and base obtusely rounded; epispore tinted brown, smooth, 1 mmm. thick; germ-pore indistinct.

Host: *Betula alba* L. On leaves. Herb. No. 596. II, III. Hanmer (Canterbury), *W. Morrison!* 2 March, 1922.

Distribution: Europe; Asia; North America. The host is an introduced species.

The aecidia occur on *Larix* spp. Plowright (1890) first worked out the connection between the aecidium on *Larix* and the uredo- and teleutospores on *Betula*. The teleutospores germinate the season following their production.

3. PUCCINIASTRUM Otth.

Otth, *Mitth. d. Nat. Gesellsch. in Bern*, p. 71, 1861.

Phragmopsora Magn., *Hedw.*, vol. 14, p. 123, 1875. *Thekopsora* Magn., *l.c.*

Heteroecious. Cycle of development includes 0, I, II, III.

0. Spermogones flattened-globose, without ostiolar filaments.

I. Aecidia with definite peridia, erumpent. Peridia cylindrical. Aecidiospores elliptical; epispore hyaline, thin, verruculose, except on one side where it is smooth and thinner; germ-pores indistinct.

II. Uredosori surrounded by a delicate hyaline peridium, opening by an apical pore, subepidermal. Uredospores borne singly on pedicels, obovate or elliptical; epispore hyaline, echinulate; germ-pores indistinct.

III. Teleutosori indehiscent, forming definite layers beneath the epidermis. Teleutospores 2–4-celled by vertical septa in two planes, elliptical or prismatic; epispore smooth, coloured; germ-pore indistinct.

Distribution: Europe; Asia; North and South America.

The following indigenous species is the sole representative of the genus that has been collected in New Zealand.

Germination as in *Melampsora*, save that as a rule only one basidium is produced from any one spore, whether 1- or 4-celled.

1. **Pucciniastrum pustulatum** Dietel. (Fig. 98.) Onagraceae.

Diet. in Engler and Prantl *Nat. Pflanzenfam.*, vol. I 1**, p. 47, 1900.

Uredo pustulata Pers., *Syn. Fung.*, p. 219, 1801. *U. Epilobii* DC., *Fl. Fr.*, vol. 6, p. 73, 1815. *Caeoma Epilobii* Link., in *Willd. Sp. Pl.*, vol. 6, p. 29, 1825. *Pucciniastrum Epilobii* Otth., *Mitth. Nat. Ges. Bern*, p. 72, 1861. *Melampsora pustulata* Schroet., *Krypt. Fl. Schles.*, vol. 3, p. 364, 1887. *Pucciniastrum Abieti-Chamaenerii* Kleb., *Jahrb. Wiss. Bot.*, vol. 34, p. 387, 1900.

0. Spermogones hypophyllous, flattened, abundant, subcuticular.

I. Aecidia hypophyllous, mostly in two rows corresponding to the white lines of the leaf, 0·25 mm. diam. Peridia hyaline, 1 mm. high, dehiscing by longitudinal fissure or irregular rupture of the apex, cylindrical, erect, not revolute, margin lacerate, hyaline. Spores obovate or subglobose, 13–22 × 10–14 mmm.; epispore hyaline, finely and moderately verruculose, with an elongated smooth area on one side, 1–1·5 mmm. thick.

II. Uredosori amphigenous, chiefly hypophyllous, scattered, or frequently crowded in small groups which are seated on irregular discoloured spots, sulphur-yellow, orbicular, 0·1–0·3 mm. diam., bullate, immersed, somewhat pulverulent, opening by an apical pore. Peridia flattened-globose, delicate, hyaline. Spores obovate, polygonal, or elliptical, 15–24 × 10–15 mmm.; epispore hyaline, finely and moderately echinulate, 1 mmm. thick, cell-contents pallid orange; germ-pores indistinct; paraphyses absent.

III. Teleutosori hypophyllous, flattened, 0·25 mm. diam., scattered or confluent, irregular, chestnut-brown, indehiscent. Spores cylindrical or prismatic, 17–35 × 7–14 mmm.; apex obtusely rounded or truncate, thickened to 3 mmm., base truncate; epispore smooth, chestnut-brown, 1 mmm. thick; germ-pore indistinct.

Host: *Epilobium pubens* A. Rich. On leaves. Herb. No. 756. II. Tiritea, Palmerston North (Wellington), 300 m., *G. H. C.* 3 Mar., 1921.

Distribution: Europe; North America.

The host is indigenous, and is widespread; it occurs also in Australia. (Cheeseman, 1906, p. 175.)

In Europe and North America the aecidia occur on *Abies pectinata* DC. The uredo stage has been described from New Zealand material, but the aecidia and teleuto stages have been described from material kindly supplied by Dr. J. R. Weir (herb. J. R. Weir, No. 11555) and Mrs. F. W. Patterson (U.S. Dept. Agr. Myc. Exc., Nos. 744, 745).

The uredosori are small and easily overlooked, largely on account of their being immersed in the host-tissues; their presence is, as a rule, indicated by the presence of small dead areas on the leaf.

4. Milesina Magnus.

Magn., *Ber. Deutsch. Bot. Gesell.*, vol. 27, p. 324, 1909.

Milesia White, *Scot. Nat.*, vol. 4, p. 162, 1877.

Autoecious. Cycle of development includes II, III. On Filicales.

II. Uredosori with a definite peridium, opening by an apical pore, subepidermal. Uredospores obovate or elliptical, borne singly on pedicels; epispore hyaline, thin, echinulate; germ-pores indistinct.

III. Teleutosori subepidermal, intracellular. Teleutospores 2–4-celled by vertical septa, elliptical; epispore smooth, hyaline; germ-pores indistinct, apical.

Distribution: Europe; North America.

The genus is confined to the Filicales. Apparently the teleutospores are rare in nature, as they appear to have been collected but once. Prior to their discovery this genus was known as *Milesia*, but, as it was erected on an imperfect stage that may have belonged to any one of several genera, it has been relegated to synonymy.

Besides *Milesina*, *Hyalopsora* Magn. and *Uredinopsis* Magn. (both included in the Melampsoraceae) are also confined to the Filicales. Of these two, *Hyalopsora* differs from *Milesina* in the peridium being absent, and the germ-pores of the uredospores being numerous and conspicuous; the teleutosori are similar to *Milesina*. In *Uredinopsis* two kinds of uredospores occur, both enclosed in peridia; the first type of uredospore is subangular, and has a hyaline roughened epispore; the second type consists of fusoid uredospores, the apex of each spore being crowned with an elongated sharply-pointed hyaline papilla, which may be as long again as the spore; the teleutospores are solitary, extracellular, septate, and appear to be scattered—without arrangement into sori throughout the mesophyll-cells of the host.

1. **Milesina Histiopteridis** n. sp. (Text-fig. 101, and Plate 1, fig. 5.)
Polypodiaceae.

II. Uredosori hypophyllous, scattered, or more commonly crowded in groups which are linear, intercostal, and up to 15 mm. long, seated on irregular discoloured spots visible on the upper surface, 0·25–0·5 mm. diam., orbicular, bullate, covered by the epidermis, opening by an irregular apical pore. Peridium flattened-globose, ostiolate, composed of obovate, hyaline cells, outer wall coarsely and densely verruculose. Spores obovate, elliptical, or polygonal, 18–26 × 14–18 mmm.; epispore hyaline, moderately and finely verrucose, 0·75–1 mmm. thick, cell-contents colourless, vacuolate; germ-pores indistinct.

III. Unknown.

Host: *Histiopteris incisa* (Thunb.) J. Sm. (= *Pteris incisa* Thunb.). On fronds. Herb. Nos. 772, 774. II. Karori (Wellington), 400 m., *E. H. Atkinson!* 27 April, 1922. Kelburn (Wellington), 120 m., *E. H. Atkinson! G. H. C.* 17 Sept., 1922. (Type.)

The very thin, moderately and finely verrucose epispore serves to separate this from other species of the genus. The rust is exceedingly common in the localities where it has been collected; in fact, scarcely a frond could be obtained free from the dead areas in which the uredosori are embedded.

IV. UREDINALES IMPERFECTI.

Under this heading are grouped all those forms (such as *Aecidium*, *Uredo*, &c.) belonging to the cycle of species whose teleutospore stage is unknown. These various forms were at one time believed to be separate entities, and accordingly were named and described separately, even when associated on the same host. As a result of the classical experiments performed by De Bary (1865), numerous investigators began to experiment with cultures and link up the various forms with their teleutospore or perfect form, and so a great number of the names applied to the different forms were gradually relegated to synonymy. In many cases, however, despite extensive cultural experiments, certain forms still remain unconnected with any teleutospore stage, in consequence of which it is

necessary to maintain form-genera to contain these. Again, in any country where little or no cultural work has been performed (as in New Zealand and Australia), many of these forms appear in systematic papers dealing with the Uredinales. It is usual to assume, when a certain aecidium or uredo stage is regularly found in proximity with the teleutosori, that this (or these) form belongs to the cycle to which the teleutospores in question belong. This is not a safe practice to follow, and much caution is necessary, as forms have frequently been found associated with teleutospores which later investigators have proved to belong to some entirely different fungus. Field investigations generally give some indication as to the probable relationships of the forms found on the same or adjacent hosts, so that in many cases it becomes a simple matter to supplement these observations with cultural experiments.

Five forms are generally recognized, as follows: *Aecidium*, *Caeoma*, *Peridermium*, *Roestelia*, and *Uredo*. Their characters may be summarized in the following key:-

KEY TO FORM-GENERA.

Spores catenulate.
  Peridium present.
    On Gymnospermae .. .. *Peridermium.*
    On Angiospermae.
      Epispore coloured brown: germ-pores conspicuous .. *Roestelia.*
      Epispore hyaline or tinted yellow: germ-pores indistinct *Aecidium.*
  Peridium absent .. .. *Caeoma.*
Spores borne singly on distinct pedicels .. .. .. *Uredo.*

Of these form-genera two only are discussed in this paper. *Peridermium* occurs in the cycle of *Coleosporium*, *Cronartium*, and *Melampsoridium*; it is confined to the Coniferae. *Roestelia* occurs only in the cycle of *Gymnosporangium*; it merges into *Aecidium*, but is separated on account of the horn-like peridium, brown-coloured epispore, and conspicuous germ-pores. *Caeoma* occurs in the cycle of *Phragmidium*, *Melampsora*, and *Gymnoconia*. It is characterized by the absence of a peridium, and by the fact that the spores are catenulate; in certain genera the caeomata are surrounded by paraphyses. *Aecidium* and *Uredo* are discussed more fully below.

1. AECIDIUM Persoon.

Pers. in J. F. Gmel., *Syst. Nat.*, vol. 2, p. 1472, 1791.

0. Spermogones immersed, flask-shaped, with protruding ostiolar filaments, honey-coloured, preceding or accompanying aecidia.

I. Aecidia at first immersed, becoming erumpent, cupulate or cylindrical, scattered, or grouped, when usually seated on somewhat inflated spots. Peridia hyaline, less frequently tinted yellow, margins erect or revolute, dentate or lacerate, seldom entire, dehiscing by the irregular rupture of the apex; formed of polygonal or rhombohedral cells which are striate or verruculose on one surface, hollow, colourless or with the central cavity filled with an oily and coloured matrix, usually overlapping. Aecidiospores catenulate, polygonal, elliptical or subglobose; epispore commonly hyaline, seldom tinted yellow, usually verruculose, with numerous scattered indistinct germ-pores.

Distribution: World-wide.

This form occurs in the cycle of certain species of *Uromyces* and *Puccinia*. The mycelium is frequently perennial, and usually causes etiolation and distortion of the host. As time permits I hope to work out the cycles of all New Zealand Uredinales by the aid of cultures, so that many of the forms listed here will doubtless be later listed as synonyms.

Eleven species of *Aecidium* are recorded here; of these, nine are endemic and two indigenous.

KEY TO THE FORM-SPECIES OF AECIDIUM.

Host belonging to the family Ranunculaceae.	
Aecidia on large distorted areas	1. *A. otagense.*
Aecidia in small groups, not on distorted areas ..	2. *A. Ranunculacearum.*
Host belonging to the family Leguminosae	3. *A. kowhai.*
Host belonging to the family Tiliaceae	4. *A. Milleri.*
Host belonging to the family Myoporaceae	5. *A. Myopori.*
Host belonging to the family Plantaginaceae	6. *A. Plantaginis-variae.*
Host belonging to the family Rubiaceae	7. *A. hupiro.*
Host belonging to the family Compositae.	
Epispore minutely verruculose.	
Aecidia crowded in distorted areas	11. *A. Macrodontae.*
Aecidia scattered	9. *A. Celmisiae-petiolatae.*
Epispore covered with deciduous tubercules.	
Spores obovate or elliptical	8. *A. Celmisiae-discoloris.*
Spores elongate-elliptical	10. *A. Celmisiae-Petriei.*

1. **Aecidium otagense** Lindsay. (Fig. 102.) Ranunculaceae.

Linds., *Trans. Roy. Soc. Edinb.*, vol. 24, p. 430, 1866.

0. Spermogones associated with the aecidia, immersed, honey-coloured.

I. Aecidia amphigenous, caulicolous, petiolicolous and sepalicolous, crowded in inflated distorted areas which may attain a length of 15 cm., orange. Peridia cupulate, shortly erumpent, 0·5–1 mm. diam., margins revolute, yellow, deeply and irregularly lacerate. Spores globose or polygonal, 23–36 mmm. diam.; epispore hyaline, delicately and closely verruculose, 0·75 mmm. thick, cell-contents granular, orange.

Hosts:

Clematis indivisa Willd. On leaves, stems, petioles, and sepals Herb. Nos. 188, 434. Lake Horowhenua, Levin (Wellington), 30 m., *E. H. Atkinson!* 26 Oct., 1919. Peel Forest (Canterbury), *H. H. Allan!* 8 Nov., 1919. Manawatu Gorge (Wellington), 150 m., *J. W. Whelan!* 29 Sept., 1921. Putara, Eketahuna (Wairarapa), *H. Watson!* 8 Nov., 1921.

Clematis Colensoi Hook. f. On stems and petioles. Herb. No. 231. Miramar (Wellington), 20 m., *J. W. Bird!* 5 Nov., 1920.

Distribution: Endemic; common throughout.

The hosts are endemic, and are abundant throughout. (Cheeseman, 1906, pp. 2, 3.)

This rust forms conspicuous distorted areas, many centimetres long, on the stems and leaves of the hosts. The mycelium is perennial, so that once a plant has become infected the rust appears season after season. The specimens on *Clematis Colensoi* are badly infected with *Tuberculina persicina* (Ditm.) Sacc. (see Appendix, p. 50). Lindsay records the rust upon *Clematis hexasepala* DC.

The aecidia of this species are formed within the host-tissues in the vicinity of the phloem, and all stages may be obtained from immature to fully-developed peridia containing numerous spores. As they develop, the peridia move towards the periphery of the stem, and prior to dehiscence may be found fully developed lying beneath the epidermis. That they are mature is evidenced by the behaviour of the spores, for on being placed in water these give rise to infection hyphae.

2. Aecidium Ranunculacearum De Candolle. (Text-fig. 103, and Plate 1, fig. 8.)

DC., *Fl. Fr.*, vol. 6, p. 97, 1805.

0. Spermogones amphigenous, crowded in small groups, mixed with the aecidia, immersed, honey-coloured.

I. Aecidia amphigenous and petiolicolous, crowded in scattered groups, which are seated on slightly inflated spots visible on the opposite surface, on leaves the groups are orbicular and up to 5 mmm. diam., on stems they are elliptical and up to 10 mm. long; orange. Peridia cupulate, immersed, and partly erumpent, 0·25 mm. diam., margins 0·5–1 mm. high, erect, slightly expanded, not revolute, brittle, white, finely lacerate. Spores polygonal, elliptical, or subglobose, 20–37 × 18–28 mmm.; epispore hyaline, closely and minutely verruculose, 1 mmm. thick, cell-contents pallid orange, granular.

Hosts :-

Ranunculus depressus T. Kirk. On leaves and petioles. Herb. No. 81. Mount Guinevere (Canterbury), *W. D. Reid !* 15 Oct., 1919.

Ranunculus geraniifolius Hook. f. Herb. No. 315. Mount Hector (Wellington), 1,500 m., *E. H. Atkinson !* 6 Feb., 1921.

Ranunculus insignis Hook. f. Herb. No. 372. Mount Dennan (Wellington), 1,500 m., *E. H. Atkinson !* 7 Jan., 1922.

Ranunculus Lyallii Hook. f. Herb. No. 81. Waimakariri glaciers, *T. Kirk !* Jan., 1883. McKinnon's Pass (Otago), *E. H. Atkinson !* 16 Jan., 1920. Sugarloaf, Cass (Canterbury), 650 m., *W. D. Reid ! N. R. Foy !* 20 Jan., 1922. Punch-bowl Falls, Arthur's Pass (Canterbury), 1,000 m., *E. H. Atkinson !* 15 Nov., 1922.

Ranunculus nivicola Hook. Herb. No. 496. Mount Egmont (Taranaki), 1,200 1,500 m., *W. D. Reid ! N. R. Foy !* 2 Jan., 1922.

Ranunculus pachyrrhizus Hook. f. Herb. No. 372. Lake Harris (Otago), 1,100 m., *W. D. Reid !* 6 May, 1921.

Ranunculus repens L. Herb. No. 81. Weraroa (Wellington), 100 m., *E. H. Atkinson ! G. H. C.* 3 Oct., 1919. Sandhills, Levin (Wellington), 30 m., *E. H. Atkinson ! G. H. C.* 14 Oct., 1922.

Distribution : World-wide.

With the exception of *Ranunculus repens* L. all the hosts are endemic. They are all confined to the mountain-ranges. *R. insignis* and *R. geraniifoliis* occurs in both Islands; *R. nivicola* is confined to the North Island, and *R. Lyallii*, *R. pachyrrhizus*, and *R. depressus* to the South Island. (Cheeseman, 1906, pp. 9–24.)

The aecidium on *R. repens* may belong to the cycle of any one of several species—for example, *Uromyces Dactylidis* Otth, *U. Poae* Rab., and *Puccinia Magnusiana* Koern. As its connection with those species mentioned above which occur in New Zealand has not yet been worked out, it is retained here for the present. The forms on the several hosts discussed above do not agree with one another in all particulars, differing slightly in the size of the spores as well as in minor details of the peridia; these differences are so slight, and merge one into the other so closely, that it is not possible to separate any one form as being sufficiently distinct to warrant its being raised to specific or even varietal rank.

(A drawing of a spermogone of this species is given in *Trans. N.Z. Inst.*, vol. 54, p. 620). On *Ranunculus Lyallii* the spermogones precede the aecidia, and may frequently be found arranged in small groups, quite covering the surfaces of the leaves.

3. Aecidium kowhai n. form-sp. (Text-fig. 104, and Plate 1, fig. 10.)
Leguminosae.

0. Unknown.

I. Aecidia caulicolous, crowded in longitudinal groups, seated on fusiform swellings up to 7 cm. long, forming large fastigiate distortions, orange-yellow. Peridia cupulate, shortly erumpent, standing above the surface 0·25 mm., 0·5 mm. diam., expanded and slightly revolute, becoming lacerate, finally eroded, tinted yellow. Spores polygonal or elliptical, 27-32 × 18-21 mmm.; epispore hyaline, densely and minutely verruculose, 1 mmm. thick, cell-contents granular, lemon-yellow.

Host: *Edwardsia tetraptera* (J. Miller) Oliver (= *Sophora tetraptera* J. Mill.). On branches. Herb. No. 763. Brightwater (Nelson), 200 m., *C. Nash! W. C. Hyde! G. H. C.* 18 May, 1922. (Type.)

The host is indigenous and widespread; it occurs also in Lord Howe Island, Easter Island, Juan Fernandez, and Chile. (Cheeseman, 1906, p. 123.)

This rust forms conspicuous "witch's-brooms" on the host. A branch becomes infected near the tip, and further outward growth is prevented. In the vicinity of the infected area numerous short laterals are produced; these in turn may give rise to tertiary laterals, until the whole assumes a dense and shrubby appearance. Infected shoots become swollen to several times their normal thickness, and in these inflated areas the aecidia appear. The mycelium is perennial, and material may be collected from infected plants throughout the year.

I am indebted to Mr. C. Nash and Mr. W. C. Hyde for assistance in procuring these specimens.

4. Aecidium Milleri n. form-sp. (Text-fig. 105, and Plate 1, fig. 7.)
Tiliaceae.

0. Unknown.

I. Aecidia hypophyllous, in minute scattered groups, 3-6 in a group, seated on pallid spots visible on the upper surface, pallid orange. Peridia cupulate, erumpent, 0·25 mm. diam., margins erect, not expanded or revolute, minutely dentate, white. Spores subglobose or polygonal, 20-26 × 17-23 mmm.; epispore hyaline, minutely and densely verruculose, 1 mmm thick, cell-contents tinted yellow, vacuolate.

Host: *Aristotelia serrata* (Forst.) Oliver (= *A. racemosa* (A. Cunn.) Hook. f.). On leaves. Herb. No. 776. Pokaka (Waimarino County), 800 m., *D. Miller!* 10 Feb., 1922. (Type.)

The host is endemic, and is widely spread throughout the lowland forests. (Cheeseman, 1906, p. 83.)

This species is named in honour of the collector, David Miller, Government Entomologist, Biological Laboratory, Wellington.

The aecidia occur in small groups of 3-6, each group being somewhat angular, and about 1 mm. in diameter.

5. Aecidium Myopori n. form-sp. (Text-fig. 106, and Plate 1, fig. 11.)
Myoporaceae.

0. Unknown.

I. Aecidia caulicolous, truncicolous, petiolicolous, and on inflorescences and drupes, seated on inflated fusiform areas up to 15 cm. long, crowded in linear groups, orange. Peridia erumpent, cylindrical, standing above the surface about 4 mm., 1 mm. diam., margins slightly expanded but

not revolute, deeply and irregularly lacerate, tinted orange, bleaching white with age. Spores obovate, elliptical, irregularly polygonal or less commonly lachrymiform, 21–45 × 17–20 mmm.; epispore hyaline, finely and closely verruculose, 1 mmm. thick, cell-contents reddish-orange, germ-pores indistinct.

Host: *Myoporum laetum* Forst. f. On branches, trunks, petioles, inflorescences, and drupes. Herb Nos. 404, 777. Palmerston North (Wellington), 250 m., *G. H. C.* Feb., May, Dec., 1921; Feb., May, 1922. (Type.) Woodside Creek, Wharanui (Marlborough), *E. H. Atkinson!* 3 Nov., 1922.

The host is endemic, and is widespread. (Cheeseman, 1906, p. 563.)

This species forms large fusiform swellings on the branches of the host; as a rule it occurs on laterals, forming "witch's-brooms," but it is not confined to these, as I have collected it on large trunks 30 cm. in diameter. The peridia resemble those of the form-genus *Roestelia*, but only in size and shape, for they dehisce apically and not throughout their length; moreover, the spores are characteristic of *Aecidium*, the epispore being hyaline and minutely verruculose, and the germ-pores are indistinct. The spores vary considerably in size and shape; the measurements given above are taken from average spores, for if the lachrymiform ones were measured they would give an entirely erroneous impression as to the average size, they being more than twice as long as the average spores

It is probable that the mycelium is perennial, as the fungus may be obtained throughout the year from infected plants.

6. Aecidium Plantaginis-variae McAlpine. (Fig. 107.) Plantaginaceae.

McAlp., *Rusts Aust.*, p. 195, 1906.

0. Spermogones amphigenous, chiefly epiphyllous, immersed, numerous.

I. Aecidia amphigenous and petiolicolous, scattered or gregarious, orange-yellow. Peridia slightly erumpent, cupulate, 0·2–0·25 mm. diam., tinted cream, margins slightly expanded, not revolute, minutely dentate. Spores subglobose, polygonal, or elliptical, 20–30 × 18–22 mmm., epispore hyaline, densely and minutely verruculose, 1 mmm thick, cell-contents granular, yellow.

Host: *Plantago spathulata* Hook. f. On leaves and petioles. Herb. No. 275. Burke's Pass (Canterbury), *W. D. Reid!* 18 Nov., 1919.

Distribution: Victoria; New South Wales; Tasmania.

The host is endemic, and, although not uncommon in the South Island, is confined to a few localities in the North. (Cheeseman, 1906, p. 571.)

This species is characterized by the scattered, small-sized aecidia.

7. Aecidium hupiro n. form-sp. (Text-fig. 109, and Plate 1, fig. 9.) Rubiaceae.

0. Spermogones amphigenous, immersed, honey-coloured, surrounded by the aecidia.

I. Aecidia hypophyllous, crowded in irregularly-circular groups, seated on discoloured and slightly-inflated areas visible on the upper surface, yellow. Peridia erumpent, cylindrical, 1 mm. high, 0·4–0·5 mm. diam., margins erect, not revolute, irregularly lacerate, tinted yellow. Spores polygonal or elliptical, 42–50 × 34–40 mmm.; epispore hyaline, densely and coarsely verruculose, 2–5·5 mmm. thick, cell-contents coarsely granular, pallid yellow.

Host: *Coprosma foetidissima* Forst. On leaves and petioles. Herb. No. 771. Alpha Hut, Mount Hector (Wellington), 1,700 m., *H. Hamilton! J. G. Myers!* 15 Feb., 1921.

The host is endemic, and is abundant throughout. (Cheeseman, 1906, p. 259.)

The upright cylindrical peridia and large size of the spores serve to characterize this species.

8. **Aecidium Celmisiae-discoloris** n. form-sp. (Text-fig. 111, and Plate 2, fig. 2.) Compositae.

0. Spermogones scattered, sparse, epiphyllous, immersed.

I. Aecidia amphigenous, chiefly epiphyllous, orange-yellow, scattered or arranged in small orbicular groups. Peridia cylindrical, erumpent, standing 1 mm. above the leaf-surface, 0·1 mm. diam., margins incurved, at first dentate, becoming deeply lacerate, white. Spores subglobose, elliptical, or obovate, 36–42 × 28–34 mmm.; epispore hyaline, covered with densely-packed deciduous tubercules, 3 mmm. thick, cell-contents orange-yellow, granular.

Hosts:

Celmisia discolor Hook. f. On leaves. Herb. No. 384. Mount Peel (Canterbury), 900 m., *H. H. Allan!* 6 March, 1921. Tooth Peaks (Otago), *W. D. Reid!* 7 April, 1921. (Type.)

Celmisia Sinclairii Hook. f. Herb. Nos. 385, 435. Lake Harris track (Otago), 1,000 m., *W. D. Reid!* 6 May, 1921. Mount Isobel, Hanmer (Canterbury), 1,200 m., *W. D. Reid!* 4 Nov., 1921.

Celmisia prorepens Petrie. Herb. No. 385. Mount Dick (Otago), 1,400 m., *W. D. Reid!* 24 April, 1921.

All three hosts are endemic, and all are confined to the mountain-ranges of the South Island. (Cheeseman, 1906, pp. 303–6.)

This species is characterized by the small cylindrical peridia, and more especially by the fact that the epispore is covered with a layer of closely-packed, coarse, deciduous tubercules. *Aecidium Celmisiae-Petriei* is the only other New Zealand species that possesses this feature.

9. **Aecidium Celmisiae-petiolatae** n. form-sp. (Text-fig. 110, and Plate 2, fig. 3.)

0. Unknown.

I. Aecidia hypophyllous, seated on discoloured spots visible on the upper surface, scattered or more commonly in small orbicular groups, pallid orange. Peridia flattened-globose, 0·25 mm. diam., immersed, margins incurved, hyaline, covered by the dense tomentum clothing the leaf-surface. Spores polygonal, elliptical, or obovate, 27–45 × 20–26 mmm.; epispore hyaline, densely and minutely verruculose, 1–1·5 mmm. thick, cell-contents granular, tinted yellow.

Host: *Celmisia petiolata* Hook. f. On leaves. Herb. No. 383. Arthur's Pass, Canterbury, 1,000 m., *E. H. Atkinson!* 15 Feb., 1920. (Type.)

The host is endemic, and is confined to the mountain regions of the southern portion of the South Island. (Cheeseman, 1906, p. 307.)

This rust is characterized by the depressed-globose aecidia, large spores, and hyaline, finely verruculose epispore. Sections are necessary to determine the shape and size of the peridium.

10. **Aecidium Celmisiae-Petriei** n. form-sp. (Text-fig. 112, and Plate 2, fig. 4.)

0. Spermogones scattered, sparse, seen only in sections.

I. Aecidia hypophyllous, in linear groups, seated on discoloured spots visible on the upper surface, forming conspicuous bullate areas beneath the tomentum of the leaf, long covered. Peridia cylindrical, 0·25 mm. diam., distorted by pressure of the overlying tomentum, margins incurved, deeply and irregularly lacerate, white. Spores elongate-elliptical, or obovate-elliptical, 36–52 × 20–25 mmm.; epispore hyaline, densely covered with deciduous tubercules, 2 mmm. thick, cell-contents granular, orange-yellow.

Host: *Celmisia Petriei* Cheesem. On leaves. Herb. No. 382. Lake Harris track (Otago), 1,100 m., *W. D. Reid!* 6 May, 1921. (Type.)

The host is endemic, and confined to the mountains of Otago. (Cheeseman, 1906, p. 311.)

This species differs from others on *Celmisia* on account of the elliptic-oblong spores, and the presence of deciduous tubercules on the epispore. The aecidia are permanently covered by the dense tomentum which clothes the leaf-surface; this soon causes the peridia to become malformed, so that sections of young specimens are necessary to determine the shape and size of the peridium.

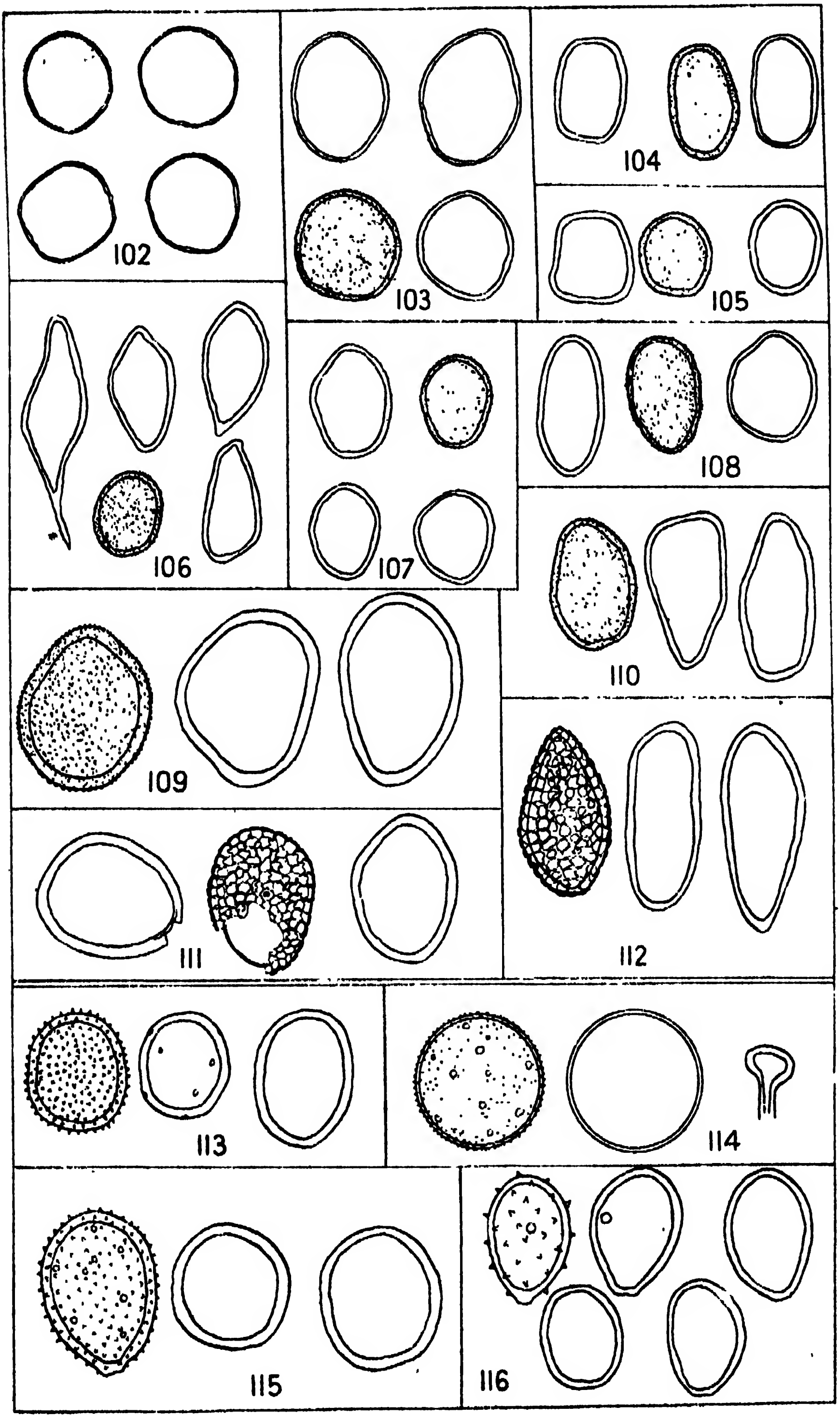
11. **Aecidium Macrodontae** n. form-sp. (Text-fig. 108, and Plate 2, fig. 1.)

0. Spermogones amphigenous, chiefly epiphyllous, sparse, associated with the aecidia.

I. Aecidia hypophyllous and petiolicolous, crowded in irregularly-shaped groups up to 10 mm. long, seated on discoloured distorted spots visible on

Fig. 102.—*Aecidium otagense* Linds. Aecidiospores from *Clematis indivisa* Willd.
Fig. 103.—*Aecidium Ranunculacearum* DC. Aecidiospores from *Ranunculus Lyallii* Hook. f.
Fig. 104.—*Aecidium kowhai* G. H. Cunn. Aecidiospores from *Edwardsia tetraptera* (J. Mill) Oliver.
Fig. 105.—*Aecidium Milleri* G. H. Cunn. Aecidiospores from *Aristotelia serrata* (Forst.) Oliver.
Fig. 106.—*Aecidium Myopori* G. H. Cunn. Aecidiospores from *Myoporum laetum* Forst. f. Note large lachrymiform spore on the left.
Fig. 107.—*Aecidium Plantaginis-variae* McAlp. Aecidiospores from *Plantago spathulata* Hook. f.
Fig. 108.—*Aecidium Macrodontae* G. H. Cunn. Aecidiospores from *Olearia macrodonta* Baker.
Fig. 109.—*Aecidium hupiro* G. H. Cunn. Aecidiospores from *Coprosma foetidissima* Forst.
Fig. 110.—*Aecidium Celmisiae-petiolatae* G. H. Cunn. Aecidiospores from *Celmisia petiolata* Hook. f.
Fig. 111.—*Aecidium Celmisiae-discoloris* G. H. Cunn. Aecidiospores from *Celmisia discolor* Hook. f. Note the coarse deciduous tubercules with which the epispore is covered.
Fig. 112.—*Aecidium Celmisiae-Petriei* G. H. Cunn. Aecidiospores from *Celmisia Petriei* Cheesem. Note decidious tubercles.
Fig. 113.—*Uredo toetoe* G. H. Cunn. Uredospores from *Arundo conspicua* Forst. f.
Fig. 114.—*Uredo Crinitae* G. H. Cunn. Uredospores from *Dichelachne crinita* (Forst. f.) Hook. f.
Fig. 115.—*Uredo karetu* G. H. Cunn. Uredospores from *Hierochloe redolens* (Forst. f.) R. Br.
Fig. 116.—*Uredo Scirpi-nodosi* McAlp. Uredospores from *Scirpus inundatus* Poir.

All figures × 500.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the upper surface, pallid yellow. Peridia immersed, the margins alone showing, 0·1–0·2 mm. diam., margins incurved, dentate, white. Spores polygonal, elliptical, or obovate, 25–37 × 18-24 mmm.; epispore hyaline, densely and rather coarsely verruculose, 1 mmm. thick, cell-contents tinted yellow, granular.

Host: *Olearia macrodonta* Baker On leaves and petioles. Herb. No. 277. The track, Clinton Valley (Otago). *E. H. Atkinson!* 18 Jan., 1920. (Type.)

The host is endemic, and is abundant throughout. (Cheeseman, 1906, p. 286.)

This species is separated from *Aecidium Oleariae* McAlp. on account of the much larger spores. Moreover, the minute immersed peridia and distorting habit are distinctive features.

2. Uredo Persoon.

Pers., *Neues. Mag. Bot. Roemer*, vol. 1, p. 93, 1794.

II. Uredosori without peridia, frequently surrounded by or mixed with paraphyses, erumpent, definite, pulverulent, bullate or pulvinate, usually surrounded by the ruptured epidermis, sometimes long covered. Uredospores borne singly on pedicels, never catenulate, globose, elliptical. or obovate; epispore hyaline or coloured, verrucose or more commonly echinulate, seldom smooth; germ-pores 2 to several, scattered or equatorial, conspicuous or indistinct, sometimes papillate. Germinating by the protrusion of a germ-tube which penetrates the host-tissues through the stomata.

Distribution: World-wide.

This form occurs in the cycle of certain species belonging to the families Pucciniaceae (excluding *Gymnosporangium*), Cronartiaceae, Coleosporiaceae, and Melampsoraceae, and in fact the commonest of all spore-forms occurring in the Uredinales.

The form-genus is characterized by the spores being borne singly on pedicels, not in chains, and by the fact that the sori are naked and not contained within peridia.

Twelve form-species are recorded in this paper; of these, nine are endemic, and the remaining three indigenous.

Key to Form-species of Uredo.

Hosts belonging to the family Gramineae.
  Spores over 30 mmm. long.
    Epispore thin, 1 mmm. .. .. 1. *U. Crinitae.*
    Epispore thick, 2 mmm. or more .. .. .. 2. *U. karetu.*
  Spores under 30 mmm. long .. .. 3. *U. toetoe.*
Hosts belonging to the family Cyperaceae .. .. 4. *U. Scirpi-nodosi.*
Hosts belonging to the family Liliaceae.
  Epispore minutely and closely echinulate .. .. 5. *U. Dianellae.*
  Epispore coarsely and sparsely echinulate .. .. 6. *U. Phormii.*
Hosts belonging to the family Chenopodiaceae .. .. 7. *U. Rhagodiae.*
Hosts belonging to the family Umbelliferae . .. 8. *U. inflata.*
Hosts belonging to the family Compositae.
  Epispore thin, 2 mmm. and under.
    Epispore closely and finely echinulate .. .. 11. *U. tupare.*
    Epispore coarsely and moderately echinulate .. 12. *U. wharanui.*
  Epispore thick, 3 6 mmm.
    Spores over 40 mmm. long .. .. .. 9. *U. Oleariae.*
    Spores under 40 mmm. long .. .. .. 10. *U. southlandicus.*

1. **Uredo Crinitae** n. form-sp. (Fig. 114.) Gramineae.

II. Uredosori amphigenous, seated on discoloured spots, scattered, seldom confluent, elliptical, 1 mm. long, reddish-orange, pulverulent, surrounded by the ruptured epidermis. Spores globose or subglobose, 38–41 mmm. diam.; epispore hyaline, closely and finely echinulate, 1 mmm. thick, cell-contents orange-yellow, granular; germ-pores scattered, numerous (12–18), conspicuous; mixed with and partially surrounded by numerous hyaline, capitate paraphyses.

Host: *Dichelachne crinita* (Forst. f.) Hook. f. On leaves. Herb. No. 760. Akaroa (Banks Peninsula), 300 m., *W. D. Reid!* 16 Jan., 1922. (Type.)

The host is indigenous and is widespread; it occurs also in Australia and Tasmania. (Cheeseman, 1906, p. 873.)

This rust is readily distinguished from any other on the Gramineae by the large globose spores, thin hyaline finely-echinulate epispore, and numerous scattered, conspicuous germ-pores.

2. **Uredo karetu** n. form-sp. (Fig. 115.)

II. Uredosori hypophyllous, seated on dark-coloured spots visible on the upper surface, linear, 1 mm. long, seldom confluent, pulverulent, orange-yellow, surrounded by the ruptured epidermis. Spores subglobose or obovate, 34–45 × 30–35 mmm.; epispore tinted yellow, finely and moderately echinulate, 2–2·5 m. thick, cell-contents yellow, granular; germ-pores scattered, numerous (8–12), obscure.

Host: *Hierochloe redolens* (Forst. f.) R. Br. On leaves. Herb. No. 762. Sea-level, Bluff (Southland), *W. D. Reid!* 26 May, 1922. (Type.)

The host is indigenous, and is abundant in moist places throughout; it occurs also in Fuegia, Tasmania, and Victoria. (Cheeseman, 1906, p. 855.)

This rust is characterized by the large size of the spores, thick, finely-echinulate epispore, and numerous scattered obscure germ-pores. *Puccinia Hierochloae* S. Ito, a species belonging to the *P. coronata* group on account of the coronate apex of the teleutospores, differs in the uredospore stage from that described above, the uredospores of this species being much smaller (16–27 × 12–18 mmm.). It was first described from Japan by Ito (1909).

3. **Uredo toetoe** n. form-sp. (Fig. 113.)

II. Uredosori hypophyllous, scattered, seated on discoloured spots visible on the upper surface, elliptical, 0·5–1 mm. long, or confluent and up to 4 mm. long, bright reddish-brown, pulverulent, naked or surrounded by the ruptured epidermis. Spores elliptical or subglobose, 20–30 × 20–26 mmm.; epispore reddish-brown, finely and closely echinulate, 1·5–2 mmm. thick, cell-contents granular, brown; germ-pores scattered, numerous (7–12), conspicuous, papillate.

Host: *Arundo conspicua* Forst. f. On leaves. Herb. No. 759. Hokianga (Auckland), *E. B. Levy!* 24 Feb., 1921. Sandhills, Levin (Wellington), 16 m., *E. H. Atkinson! G. H. C.* 12 Oct., 1922. (Type.)

The host is endemic, and is abundant throughout. (Cheeseman, 1906, p. 893.)

The rust is characterized by the conspicuous reddish-brown sori, closely and finely echinulate epispore, and numerous scattered, conspicuous, papillate germ-pores.

4. Uredo Scirpi-nodosi McAlpine. (Fig. 116.) Cyperaceae.

McAlp., *Rusts Aus.*, p. 202, 1906.

II. Uredosori caulicolous, scattered or crowded, elliptical, up to 2 mm. long, cinnamon-brown, bullate, pulverulent, becoming exposed by the longitudinal fissuring of the epidermis. Spores elliptical, obovate, or subglobose, 25–35 × 20–25 mmm.; epispore tinted cinnamon-brown, coarsely and sparsely echinulate, 2–2·5 mmm. thick, cell-contents granular, cinnamon-brown; germ-pores equatorial, 2, conspicuous.

Host: *Scirpus inundatus* Poir. On stems. Herb. Nos. 282, 325. Seashore (Wellington), *E. H. Atkinson!* 17 April, 1920; 27 Jan., 1921. Bog, Tiritea, Palmerston North (Wellington), 300 m., *G. H. C.* 4 March, 1921. Seashore, Bluff (Southland) *W. D. Reid!* 26 May, 1922.

Distribution: Victoria.

The host is indigenous, and is widespread, occurring in marshy localities from sea-level to 1,000 m.; it occurs also in Australia, Malay Archipelago, and temperate South America. (Cheeseman, 1906, p. 775.)

The rust forms conspicuous bullate sori on the stems; these are usually severely infected with *Darluca filum* Cast. Characterized by the thick coloured epispore and the two equatorial conspicuous germ-pores.

5. Uredo Dianellae Dietel. (Fig. 117.) Liliaceae.

Diet., *Hedw.*, vol. 37, p. 213, 1898.

Not *Uredo Dianellae* Rac., *Parasit. Algen & Pilze Javas*, vol. 2, p. 33, 1900.

II. Uredosori hypophyllous, seated on reddish-purple spots which are visible on the upper surface, scattered, elliptical, 1 mm. long, or confluent and up to 5 mm. long, pulverulent, pallid brown, bullate, surrounded by the ruptured epidermis. Spores subglobose or broadly elliptical, 16–22 mmm. diam.; epispore hyaline, densely and finely echinulate, 1·5 mmm. thick, cell-contents granular, yellow; germ-pores scattered, numerous (6 8), obscure.

Host: *Dianella intermedia* Endl. On leaves. Herb. No. 762. Horahora Rapids, Waikato River (Auckland), *E. H. Atkinson!* 26 March, 1921.

Distribution: Java; Ceylon; Hong-Kong.

The host is indigenous, and is widespread; it occurs also in Norfolk Island and Polynesia. (Cheeseman, 1906, p. 715.)

Characterized by the small spores, densely and finely echinulate hyaline epispore, and numerous scattered, obscure germ-pores.

Although this form does not agree in all particulars with the description published by Dietel, it resembles it too closely to allow of its being separated as a distinct species. It agrees in most particulars with *U. Dianellae* Rac., so that this form is better classed as a synonym.

6. Uredo Phormii n. form-sp. (Fig. 118.)

II. Uredosori hypophyllous, seated on discoloured spots visible on the upper surface, scattered or more commonly crowded into irregular groups often covering the entire under-surface of the leaf, elliptical, 1 mm. long, or confluent and up to 6 mm. long, ferruginous, bullate, pulverulent, surrounded and partially covered by the ruptured epidermis. Spores obovate, elliptical, or subglobose, 21–30 × 17–22 mmm.; epispore golden-brown, coarsely and sparsely echinulate, 2·5–3 mmm. thick, cell-contents brown, granular; germ-pores scattered, 3–5, commonly 3, conspicuous.

Hosts :—

Phormium tenax Forst. On leaves. Herb. Nos. 755, 775. Plimmerton (Wellington), 20 m., *R. Waters! H. Drake! G. H. C.* 16 Jan., 1922. (Type.)

Phormium Colensoi Hook. f. Herb. No. 757. Tokaanu Waiouru Road, Taupo, 800 m., *E. H. Atkinson!* 11 March, 1922.

Both hosts are indigenous, the former being common throughout, and extending to Norfolk Island, whilst the latter is endemic. (Cheeseman, 1906, p. 716.)

This rust is characterized by the small spores, coloured coarsely and sparsely echinulate thick epispore, and conspicuous scattered germ-pores. Severely infected leaves are useless for milling purposes.

7. **Uredo Rhagodiae** Cooke and Massee. (Fig. 119.) Chenopodiaceae.

Cke. et Mass., *Grev.*, vol. 15, p. 99, 1887.

II. Uredosori amphigenous, chiefly hypophyllous, scattered, bullate, reddish-brown, orbicular, 1 1·5 mm. diam., long covered, at length free and surrounded by the ruptured epidermis. Spores globose or obovate, 22 30 × 20 23 mmm.; epispore cinnamon-brown, sparsely and moderately echinulate, 2 2·5 mmm. thick, cell-contents granular, cinnamon-brown; germ-pores scattered, numerous (8 10), conspicuous.

Host: *Rhagodia nutans* R. Br. On leaves. Herb. No. 294. Seashore, Seatoun (Wellington), *E. H. Atkinson! G. H. C.* 27 Jan., 1921.

Distribution: Victoria.

The host is indigenous, and is not uncommon on rocky areas near the sea-coast; it occurs also in eastern Australia. (Cheeseman, 1906, p. 578.)

The spore-measurements (20 × 15 mmm.) given by Cooke and Massee are much too small, as has been ascertained by McAlpine (1906, p. 207) from an examination of part of the type material.

8. **Uredo inflata** Cooke. (Fig. 120.) Umbelliferae.

Cke., *Grev.*, vol. 19, p. 48, 1890.

II. Uredosori amphigenous, crowded or scattered, seldom confluent, irregular in shape, usually elliptical when up to 4 mm. long, bullate, pallid ferruginous, long covered by the epidermis. Spores globose or shortly elliptical, 25–35 × 22 32 mmm.; epispore hyaline, minutely and densely verruculose (appearing smooth when wet), up to 6 mmm. thick, slightly thickened at the apex (2–3 mmm.), cell-contents granular, tinted cinnamon; pedicel persistent, hyaline, fragile, up to 25 × 5 mmm.; germ-pores indistinct.

Host: *Anisotome latifolia* Hook. f. (=*Ligusticum latifolium* Hook. f.). On leaves. Herb. No. 41. Campbell Islands, *T. Kirk!* 1890. (Type collection.)

Distribution: Campbell Islands.

The host is endemic, and confined to the Campbell and Auckland Islands. (Cheeseman, 1906, p. 215.)

This species is characterized by the almost smooth thick and hyaline epispore. This may prove to be a species of *Uromyces*, but this can be verified only by germinating the spores, and as the material at hand is too old (all attempts to germinate the spores having failed) it is retained here for the present.

9. Uredo Oleariae Cooke. (Fig. 125.) Compositae.

Cke., *Grev.*, vol. 19, p. 48, 1890.

II. Uredosori hypophyllous, seated on discoloured spots visible on the upper surface, orbicular, 1 mm. diam., pulverulent, reddish-brown, deeply seated in the dense tomentum clothing the leaf-surface. Spores subglobose, elliptical, or obovate. 42–55 × 35–40 mmm.; epispore hyaline, coarsely and sparsely echinulate, varying in thickness from 3 to 6 mmm., cell-contents granular, tinted ferruginous; germ-pores indistinct.

Host: *Olearia Lyallii* Hook. f. On leaves. Herb. No. 42. Port Ross (Auckland Islands), *T. Kirk!* 1890. (Type collection.)

Distribution: Auckland Islands.

The host is endemic, and is confined to the Auckland Islands and the Snares. (Cheeseman, 1906, p. 283.)

The published description of Cooke's is far from accurate, as the spores are stated to be 22 × 15 mmm., and the epispore to be smooth. Fortunately I have part of the type collection, and the above description has been drawn up from this. The epispore in different spores varies in thickness, and when mounted and examined in the usual manner is seen to be very irregular; when the spores are boiled for a few seconds in lactic acid the outer covering swells somewhat and a distinct inner wall becomes visible (fig. 125, *a*). The large size of the spores, together with the thick coarsely-echinulate epispore, serve to characterize the species.

10. Uredo southlandicus n. form-sp. (Text-fig. 122, and Plate 2, fig. 6.)

II. Uredosori epiphyllous, scattered evenly over the leaf-surface, orbicular, 1–2 mm. diam., bullate, golden-brown, long covered. Spores subglobose or elliptical, 28–35 × 24–28 mmm.; epispore hyaline, coarsely and sparsely echinulate, 4–5 mmm. thick, cell-contents granular, orange; germ-pores indistinct.

Host: *Olearia angustifolia* Hook. f. On leaves. Herb. No. 753. Stewart Island, *T. Kirk!* Jan., 1882. Sea-level, Bluff (Southland), *L. Cockayne!* 26 May, 1922. (Type.)

The host is endemic, and is confined to the southern part of the South Island and to Stewart Island. (Cheeseman, 1906, p. 281.)

This species is characterized by the thick, coarsely and sparsely echinulate epispore, and by the epiphyllous covered sori.

11. Uredo tupare n. form-sp. (Fig. 123.)

II. Uredosori hypophyllous, scattered, seated on pallid spots visible on the upper surface, orbicular, 1 mm. diam., orange, fading with age to pallid yellow, pulverulent, deeply seated in the dense tomentum of the leaf. Spores obovate or elliptical, 40–55 × 25–31 mmm.; epispore hyaline, closely and finely echinulate, 1·5–2 mmm., cell-contents granular, yellow; germ-pores scattered, numerous (6–8), obscure.

Host: *Olearia Colensoi* Hook. f. On leaves. Herb. Nos. 758, 773. Mount Waiopehu (Wellington), 1,700 m., *G. H. C.* 26 October, 1919. (Type.) Table-top, Mount Hector (Wellington), 1,120 m., *E. H. Atkinson!* 6 Feb., 1921. Mount Dennan (Wellington), 1,000 m., *E. H. Atkinson!* 7 Jan., 1922.

The host is endemic, and widely spread throughout the mountain areas. (Cheeseman, 1906, p. 282.)

The large-sized spores and closely and finely echinulate epispore characterize this species.

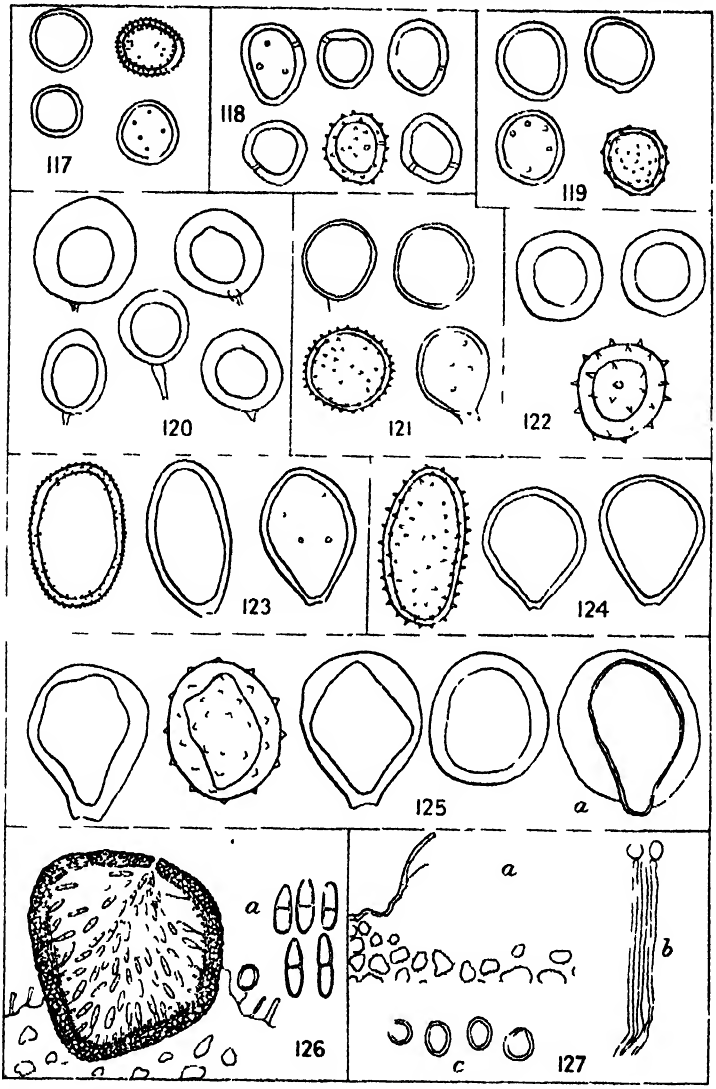


FIG. 117.—*Uredo Dianellae* Diet. Uredospores from *Dianella intermedia* Endl.
FIG. 118.—*Uredo Phormii* G. H. Cunn. Uredospores from *Phormium tenax* Forst.
FIG. 119.—*Uredo Rhagodiae* Cke. et Mass. Uredospores from *Rhagodia nutans* R. Br.
FIG. 120.—*Uredo inflata* Cke. Uredospores from *Anisotome latifolia* Hook f.
FIG. 121.—*Puccinia Celmisiae* G. H. Cunn. Uredospores from *Celmisia longifolia* Cass.
FIG. 122.—*Uredo southlandicus* G. H. Cunn. Uredospores from *Olearia angustifolia* Hook. f.
FIG. 123.—*Uredo tupare* G. H. Cunn. Uredospores from *Olearia Colensoi* Hook. f.
FIG. 124.—*Uredo wharanui* G. H. Cunn. Uredospores from *Olearia insignis* Hook. f
FIG. 125.—*Uredo Oleariae* Cke. Uredospores from *Olearia Lyallii* Hook. f. The spore on the right has been boiled for a few seconds in lactic-acid solution. Note inner wall.
FIG. 126.—*Darluca Filum* Cast. Pycnidia and conidia from the uredosori of *Puccinia Juncophila* Cke. et Mass. on *Juncus vaginatus* R. Br. Pycnidia × 200; conidia × 480.
FIG. 127.—*Tuberculina persicina* Sacc. on *Aecidium otagense* Linds., from *Clematis Colensoi* Hook. f. (*a*) Part of a sporodochium, × 24; (*b*) conidiophores, × 300; (*c*) conidia, × 400.

All figures × 400, with the exception of figs. 126 and 127.

12. Uredo wharanui n. form-sp. (Fig. 124.)

II. Uredosori hypophyllous, seated on pallid spots visible on the upper surface, orbicular, 1 mm. diam., bullate, reddish-orange, pulverulent, deeply buried in the dense tomentum of the leaf-surface. Spores elliptical or obovate, 35 55 × 26–34 mmm. ; epispore hyaline, coarsely and moderately echinulate, 2-2·5 mmm , thick, cell-contents granular, reddish-orange ; germ-pores indistinct.

Host : *Olearia insignis* Hook. f. On leaves. Herb. No. 778. Woodside Creek, Wharanui (Marlborough), *E. H. Atkinson !* 3 Nov., 1922.

The host is endemic, and is confined to the Marlborough District. (Cheeseman, 1906, p. 279.) In size and shape the spores of this species resemble the preceding ; it is separated on account of the thicker, coarsely and moderately echinulate epispore, and bright reddish-orange colour of the sori.

The following species and form-species have been recorded as occurring in New Zealand, but, as I have not seen specimens, I am unable to give descriptions ; moreover, as in most instances the published descriptions are so fragmentary as to be useless for comparative purposes, I have not included them here.

(*a.*) *Uromyces Azorellae* Cke., *Grev.*, vol. 10, p. 2, 1890.

Host: *Azorella trifoliata* Benth. et Hook. f. (*Pozoa trifoliata* Hook. f.). Collected in Hawke's Bay by Colenso.

(*b.*) *Uromcyes citriformis* Berk., *Fl. N.Z.*, vol. 2, p. 210, 1855.

Host : " On leaves of some orchid, apparently a *Thelymitra.*"

U. citriformis Bab. (*Hdbk. Fl. N.Z.*, p. 625, 1864) is an error of compilation. Mr. Mason, Imperial Bureau of Mycology, Kew, states that there are no specimens of this species at Kew or the British Museum. As no specimens are known, and as the description is too imperfect for determination, and as the host also is unknown, it would be advisable to discard this name.

(*c.*) *Uromyces scariosus* Berk., *Fl. N.Z.*, vol. 2, p. 195, 1855.

Hosts : *Geranium dissectum* L. and *G. microphyllum* Hook. f. (= *Geranium potentilloides* Hook. f.

Collected in Hawke's Bay by Colenso.

(*d.*) *Puccinia novo-zelandica* Bubak, *Sitz-ber. Boehm. Ges. Wiss.*, p. 5, 1901.
P. compacta Berk., *Fl. N.Z.*, vol. 2, p. 195, 1855.

Host : *Myosotis capitata* Hook. f.

These specimens were said to have been collected in the South Island, but the host is confined to the Auckland and Campbell Islands. (Cheeseman, 1906, p. 163.)

(*e.*) *Aecidium Anisotomes* Reich., *Ardt. Sitzungber. K. Akad. der Wissensch.*, p. 3, 1865.

Host: *Angelica geniculata* Hook. f.

Possibly *Puccinia cuniculi* G. H. Cunn., although the description does not agree with that of the aecidium of this host.

(*f.*) *Aecidium dissimenatum* Berk., *Hdbk. Fl. N.Z.*, p. 756, 1867.

Host: *Hypericum japonicum* Thunb.

McAlpine (1906, p. 200) records this rust as occurring in Australia on the same host.

(*g.*) *Aecidium monocystis* Berk., *Fl. N.Z.*, vol 2, p. 196, 1855.

Host: *Phyllachne Colensoi* Berggr. (= *Helophyllum Colensoi* Hook. f.).

McAlpine (1906, p. 197) states that this is common on *Abrotanella forsterioides* Hook. f. in the vicinity of Hobart, and doubts the determination of the host as given above; he claims that it is scarcely likely that the same species would occur on hosts belonging to the Compositae and Candolleaceae (= Stylidieae). Mr. Rodway, Government Botanist, Hobart, has written to me to the same effect; he believes that the species was in error stated to have been collected in New Zealand, and was really collected in Tasmania. Although *Abrotanella* occurs in New Zealand, all the species are endemic; so that the matter must remain at issue until the original host is correctly determined.

(*h.*) *Uredo Acaciae* Cke., *Grev.*, vol. 19, p. 3, 1890.

Host: *Acacia* sp.

The description is too incomplete for determination, but it will doubtless prove to be a species of *Uromycladium*.

(*i.*) *Uredo antarctica* Berk., *Fl. Antarct.*, p. 176, 1847.

Host: *Luzula crinita* Hook. f. The host is confined to the Auckland and Campbell Islands.

(*j.*) *Aecidium Discariae* Cke., *Grev.*, vol. 14, p. 89, 1886.

This form belongs to the cycle of *Uromyces Discariae* G. H. Cunn.

APPENDIX: FUNGI PARASITIC UPON THE UREDINALES.

In the past numerous fungi belonging to the following genera have been recorded as parasitizing the various spore-forms of the *Uredinales*:—

Phycomycetes: *Olpidium* (= *Olipidiella*).

Ascomycetes: *Mycosphaerella* (= *Sphaerella*).

Fungi Imperfecti: Sphaeropsidales—*Phyllosticta*; *Ascochyta*; *Darluca*.
Hyphomycetes—*Cladosporium*; *Fusarium*; *Fusoma*; *Macrosporium*; *Oospora*; *Ramularia*; *Tuberculina*.

Doubtless many of these will later prove to be merely saprophytic, their contiguity with a rust upon the same host-plant leading to the belief that they were parasitic upon the rust.

So far only the two species described below have been collected in New Zealand; *Darluca* is exceedingly common, especially on the uredosori of many of our rusts, but *Tuberculina* has been collected once only. Both species are included under the Fungi Imperfecti, the former belonging to the Sphaeropsidales (Sphaerioidaceae-Hyalodidymae), the latter to the Hyphomycetes (Tuberculariaceae-Amerosporae).

DARLUCA Castagne.

Cast., *Cat. Pl. Mus. Suppl.*, p. 53, 1851.

Pycnidia free, superficial, depressed, or conico-globose, obsoletely papillate, ostiolate, black; context of closely-woven thick-walled coloured hyphae. Spores (conidia) 1-septate, hyaline, elliptic-oblong or fusoid, muticate; borne singly on simple unbranched pedicels.

Habitat: Parasitic upon the spermogones, aecidia, uredosori, and teleutosori of numerous Uredinales; saprophytic upon the leaves of deciduous plants.

Distribution: Europe; North and South America; Africa; Ceylon; Japan; Australia.

Although eight species have been described, only one has been collected here. It is probable that many of these so-called species are but variable forms of *D. Filum*, as in many instances they appear to have been erected on slight differences in the size of the spores, a character too variable to be considered specific; for, as is shown below, in *D. Filum* alone the spores on different hosts range in length from 10 to 18 mmm.; furthermore, this variation may be seen in the spores from a single pycnidium.

1. **Darluca Filum** Castagne. (Text-fig. 126, and Plate 2, fig. 5.) Uredinales.

Cast., *l.c.*

Sphaeria Filum Biv.-Bern., *Bernh. Stirp. rar Sic. Manip.*, vol. 3, p. 12, 1815.
Phoma Filum Fr., *Syst. Myc.*, vol. 2, p. 547, 1823.

Pycnidia superficial or immersed, scattered or gregarious, conico-globose, elliptical, obovate, or depressed-globose, 90-120 × 60-100 mmm. diam., ostiolate, smooth, black. Conidia 1-septate, hyaline, fusoid, smooth, 10-18 × 3-6 mmm., slightly or not constricted at the septum, muticate.

Habitat: Parasitic upon the spores of the following species: *Uromyces otakou* G. H. Cunn. (II); *U. Polygoni* Fcl. (II); *Uromycladium alpinum* McAlp. (II); *Urom. notabile* McAlp. (II); *Urom. Tepperianum* (Sacc.) McAlp. (III); *Puccinia Caricis* Schroet. (II, III); *P. Chrysanthemi* Roze (II); *P. Coprosmae* Cke. (III); *P. Elymi* Westnd. (II); *P. Hoheriae* Wakef. (III); *P. Hydrocotyles* Cke. (II); *P. juncophila* Cke. et Mass. (II); *P. Morrisoni* McAlp. (II); *P. Plagianthi* McAlp. (III); *P. Poarum* Niels. (II); *P. pulverulenta* Grev. (II); *P. punctata* Link. (II); *P. whakatipu* G. H. Cunn. (II); *P. Unciniarum* Diet. et Neg. (II, III); *Phragmidium novae-zelandiae* G. H. Cunn. (I); *Phr. Potentillae* P. Karst. (I, II);

PLATE 1.

FIG. 1.—*Phragmidium Acaenae* G. H. Cunn. Caeomata and teleutosori from *Acaena microphylla* Hook. f. Arrows point to the minute teleutosori.

FIG. 2.—*Phragmidium novae-zelandiae* G. H. Cunn. Teleutosori from *Acaena novae-zelandiae* T. Kirk.

FIG. 3.—*Phragmidium Potentillae* P. Karst. Teleutosori on *Acaena Sanguisorbae* Vahl.

FIG. 4.—*Hamaspora acutissima* Syd. Teleutosori on *Rubus australis* Forst. f. Note the long and much-entwined fibrils. Arrow points to sori from which the fibrils have disappeared.

FIG. 5.—*Milesina Histiopteridis* G. H. Cunn. Uredosori on *Histiopteris incisa* (Thunb.) J. Sm. The white spots consist of numerous uredospores which have exuded from the immersed peridia.

FIG. 6.—*Melampsora Lini* Desmaz. Teleutosori on *Linum monogynum* Forst.

FIG. 7.—*Aecidium Milleri* G. H. Cunn. on *Aristotelia serrata* (Forst.) Oliver.

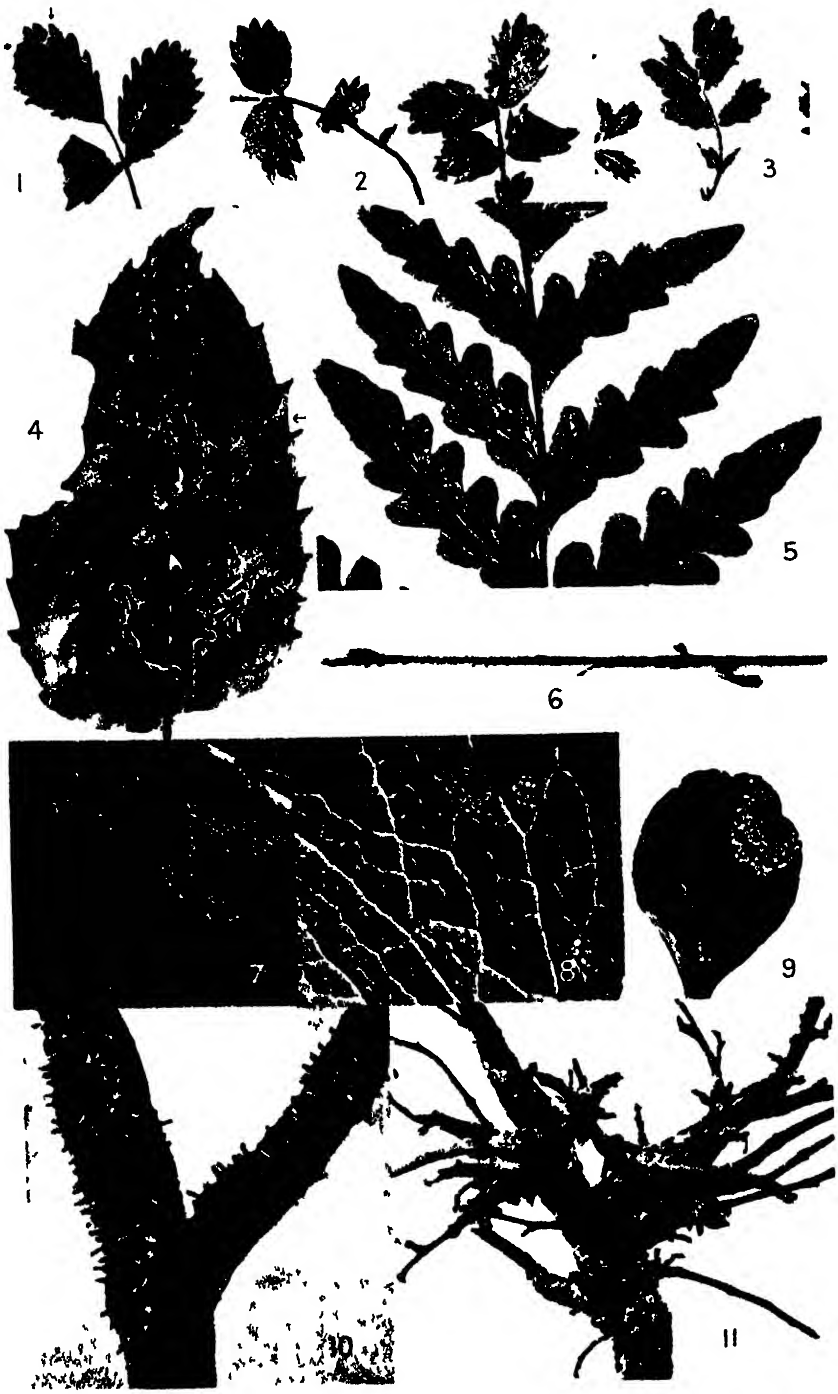
FIG. 8.—*Aecidium Ranunculacearum* DC. on *Ranunculus Lyallii* Hook. f.

FIG. 9.—*Aecidium kupiro* G. H. Cunn. on *Coprosma foetidissima* Forst.

FIG. 10.—*Aecidium kowhai* G. H. Cunn. on *Edwardsia tetraptera* (J. Mill.) Oliver. Photo by E. Bruce Levy.

FIG. 11.—*Aecidium Myopori* G. H. Cunn. on *Myoporum laetum* Forst. f.

Natural size. All photographs, with the exception of fig. 10, by the writer.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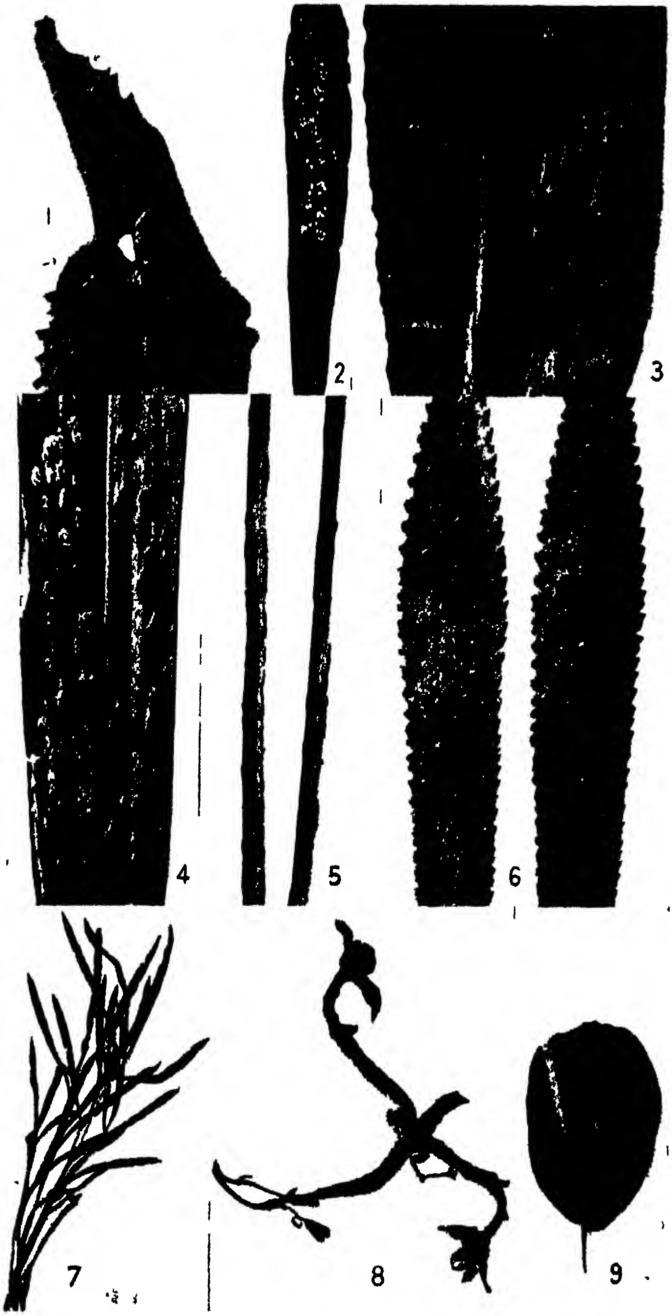
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Aecidium otagense Linds.; *A. Ranunculacearum* DC.; *Uredo Dianellae* Diet.; *U. karetu* G. H. Cunn.; *U. Phormii* G. H. Cunn.; *U. Scirpi-nodosi* McAlp.; *U. toetoe* G. H. Cunn.

Distribution: Europe; North and South America; Ceylon; Japan; Africa; Australia.

From the foregoing it will be seen that in New Zealand this species has been collected on aecidia, caeomata, uredosori, and teleutosori.

The mycelium ramifies through the sori and appears to plasmolyze and disintegrate those spores with which the hyphae come in contact; in certain sori, indeed, it is difficult to obtain any unaffected spores. Generally the pycnidia are superficial and easily seen, but in certain cases, particularly when they are parasitic upon aecidia, they are almost competely immersed, and their presence noted only when sections of the aecidia are examined. Saccardo (*Syll. Fung.*, vol. 3, p. 410, 1884) states that the spores have on either end a few fine bristles; I have failed to observe these, although I have examined numerous microtome sections of pycnidia of all ages. So common are the pycnidia on certain species that they have frequently been mistaken for spermogones, and described as such.

TUBERCULINA Saccardo.

Sacc., *Mich.*, vol. 2, p. 34, 1880.

Uredinula Speg., *Anal. Soc. Cientif. Argent.*, p. 213, 1880. *Cordalia* Gobi, *Mem. Acad. Imp. Sci. St. Petersburg*, vol. 32, p. 13, 1885.

Sporodochia plane or flattened-discoid, pulverulent, formed of closely compacted upright conidiophores, which are simple and unbranched. Spores (conidia) innate, unicellular, hyaline, smooth, subglobose.

Habitat: Parasitic upon the aecidia, uredosori, and teleutosori of Uredinales.

PLATE 2.

FIG. 1.—*Aecidium Macrodontae* G. H. Cunn. on *Olearia macrodonta* Baker.

FIG. 2.—*Aecidium Celmisiae-discoloris* G. H. Cunn. on *Celmisia discolor* Hook. f.

FIG. 3.—*Aecidium Celmisiae-petiolatae* G. H. Cunn. on *Celmisia petiolata* Hook. f. The aecidia are covered by the tomentum of the leaf, and in the photograph appear as slightly-raised linear blisters, principally to the right of the midrib.

FIG. 4.—*Aecidium Celmisiae-Petriei* G. H. Cunn. on *Celmisia Petriei* Cheesem. On the right of the midrib the groups of aecidia are covered by the tomentum, on the left the tomentum has been stripped off and the distorted peridia and spore-masses exposed.

FIG. 5.—*Darluca Filum* Cast. on *Uredo Scirpi-nodosi* McAlp. Uredosori on the left, parasitized sori on the right.

FIG. 6.—*Uredo southlandicus* G. H. Cunn. on *Olearia angustifolia* Hook. f. Note the characteristic epiphyllous, bullate, scattered sori.

FIG. 7.—*Puccinia namua* G. H. Cunn. Aecidia on *Anisotome filifolia* (Hook. f.) Cockayne and Laing.

FIG. 8.—*Tuberculina persicina* Sacc. on *Aecidium otagense* Linds. Note the flattened sporodochia surrounded by the ruptured epidermis.

FIG. 9.—*Coleosporium Fuchsiae* Cke. Uredosori on leaves of seedlings of *Fuchsia excorticata* (Forst. f.) L. f.

Natural size. Photographs by the writer. All photographs are taken from dried herbarium material.

Distribution: Europe; South America.

Although twenty species have been described, I doubt whether more than a third of this number are valid, as, judging from the published descriptions, most appear to have been separated on host-distinctions alone.

1. **Tuberculina persicina** Saccardo. (Text-fig. 127, and Plate 2, fig. 8.)

Sacc., *Fung. Ital.*, tab. 964, 1881.

Tubercularia persicina Ditm., *Sturm. Deutsch. Fl.*, vol. 1, p. 99, 1817. *Caeoma fallax* Cda., *Icon.*, vol. 5, p. 49, 1842. *Uredo lilicina* Rob., in Desm., *Ann. Sci. Nat.*, ser. 8, vol. 3, p. 11, 1847. *Cordalia persicina* Gobi, *Mem. Acad. Sci. Imp. St. Petersburg*, vol. 32, p. 18, 1885.

Sporodochia discoid, 0·1 1·25 mm. diam., immersed, surface alone showing, pulverulent, consisting of closely compacted tinted hyphae, 25–80 mmm. long, 2 5 mmm. thick. Conidia unicellular, globose, or shortly elliptical, 7–14 mmm. diam., epispore smooth, tinted dingy-violet or violet-brown, 1 mmm. thick.

Habitat: Parasitic upon *Aecidium otagense* Linds. on *Clematis Colensoi* Hook. f. Miramar (Wellington), 20 m., *J. W. Bird!* 5 Nov., 1920.

Distribution: Europe.

This fungus is conspicuous owing to the powdery nature of the spore-masses, and the purple colour of the spores and sporodochia. These are plano-discoid in shape, and are surrounded by the ruptured epidermis and partly disintegrated peridia of the aecidia: the conidiophores are closely packed together, and somewhat resemble the hymenium of *Stereum* or some similar Basidiomycete. On their apices are borne the spores, which, owing to the method of production, frequently occur in chains.

In the specimens at hand the parasite is seen frequently to infect the aecidia before they appear on the surface—*i.e.*, before they dehisce—as when sections are examined aecidia in different stages of development may be seen in all stages of infection. But by far the greater number of parasitized aecidia appear to have been infected after they have expanded, since the sporidochia of the parasite are frequently seen to be partially surrounded by portions of the revolute margins, which give a very ragged appearance to the shoots of *Clematis* upon which the aecidia are located.

Considerable confusion has arisen in the past as to the systematic position of *Tuberculina*, and in many systematic papers it has been placed under the Ustilaginaceae; in fact, certain authors state that on germination the spores give rise to promycelia [basidia] bearing sickle-shaped conidia [basidiospores]. This is not the case, however, for I have germinated the spores and find they produce long and slender hyphae.

I have little doubt but that the so-called aecidium described and figured by Plowright (1899, p. 161) as occurring in the cycle of *Puccinia Vincae* Berk. is this species. He states that the spores are finely echinulate; but Grove (1913, p. 177), in a discussion of this so-called aecidium, states that they are smooth. Grove states that the organism in question is not an aecidum, and suggests that it may be a parasite; his description agrees closely with *T. persicina*, differing only in colour, which is stated to be dark-brown with a greyish bloom. Grove also mentions that both Sydow (1904, p. 338) and Fischer (1904, p. 167) considered the sporidochia on *Puccinia Vincae* to be primary uredosori.

It is worthy of mention that the larva of a dipterous insect, *Cecidomyia uredinicola*, also parasitizes the spores of many of our species of *Uromyces*, *Puccinia*, &c. The larva is about 3 mm. in length, and is conspicuous on account of its bright reddish-orange colour. It feeds only on the spores.

LATIN DIAGNOSES OF NEW SPECIES AND FORM-SPECIES.

The following diagnoses are arranged in order of genera as they appear in this paper, but the species under each genus are arranged in alphabetical order.

1. Phragmidium Acaenae sp. nov. (Fig. 93.) Rosaceae.

0. Spermagoniis amphigenis, sparsis, raris, conicis, subflavis.

I. Caeomatiis hypophyllis, raris, rotundis, 0·5 1 mm. latis, vel ellipticis et 3 mm. longis, pulvinatis, pulverulentibus, flavis; hyalino, clavatis paraphysis cinctis. Caeomatosporis globosis, obovatis, vel ellipticis, 18 28 × 16–29 mmm.; episporio hyalino, minute tenuiter echinulato, 1-1·5 mmm. crasso, contentu flavo. vacuolato.

III. Soris teleutosporiferis hypophyllis, caulicolis, sparsis. raris, rotundis, 0·1–0·5 mm. latis, primum compactis et pulvinatis, demum pulverulentibus, splendidis-nigris, nudis, soris cum paucis sporis. Teleutosporis 4 7-cellulo, communiter 6, longis-cylindricis, 50 95 × 20-25 mmm.; apice rustice acuminato, vel rotundato, leniter ad non incrassato, saepe papillato hyalino, ad 10 mmm. longis, basi rotundato, apice et basi saepe necne attenuatis; ad septa leniter necne constrictis; episporio castaneo, 3–4 mmm. crasso, raro hyalino verrucoso; pedicello persistente, hyalino apice tincto, fistuloso, ad 50 mmm. longo, 5-9 mmm. crasso, ad basim 20 mmm. inflato, verruculoso, foramine germinis ad cellulo 2 3, conspicuo.

Hab.: In foliis vivis et petiolibus *Acaenae microphyllae* Hook. f. Horto Botanico, Gore, Southland, New Zealand. *E. B. Levy.*

2. Phragmidium novae-zelandiae sp. nov. (Fig. 92.)

0. Spermagoniis *Phr. Acaenae* similibus.

I. Caeomatiis *Phr. Acaenae* similibus.

III. Soris teleutosporiferis hypophyllis, sparsis, ellipticis ad 3 mm. longis, pulvinatis, primum pulverulentibus, demum in solide catervis conglutinaris, pallidis glauco-nigris, nudis, sporis numerosis in soris. Teleutosporis 4–8-cellulo, communiter 6–7, oblongis-cylindricis, 65–118 × 18–24 mmm.; apice acuminato, raro rotundato, leniter necne crassato, in papillo apice cellulo episporio continuato, tincto, in summa hyalino, 8 mmm. longo, basi rotundato vel leviter attenuato; ad septa non constrictis; episporio fusco-nigris, 4–6 mmm. crasso, rustice solide verrucoso; pedicello persistente, hyalino apice tincto, ad 100 mmm. longo, 4–6 mmm. crasso, basim leniter necne inflato, verruculoso; foramine germinis ad cellulo 2–4, conspicuo.

Hab.: In foliis vivis *Acaenae novae-zelandiae* T. Kirk. Queenstown, Otago, New Zealand. *W. D. Reid.*

3. **Phragmidium subsimile** sp. nov. (Fig. 90.)

0. Spermagoniis hypophyllis, sparsis, raris, flavidulis.

I. Caeomatiis hypophyllis, sparsis, raris, rotundis, ad 0·5–3 mm. latis, pulverulentibus, flavis; paraphysibus hyalinis incurvatis clavatis cinctis. Caeomatosporis subglobosis, 18–22 mmm. latis; episporio hyalino, solide tenuiter verrucoso, 1·5–2 mmm. crasso, contentu vacuolato, luteo.

III. Soris teleutosporiferis hypophyllis, raris, ellipticis, ad 2 mm. longis, pulverulentibus, glauco-nigris, in soris sporis numerosis. Teleutosporis 5–7-cellulo, communiter 6, oblongo-teretis, 57–70 × 22–30 mmm.; apice rotundato, non incrassato, saepe prominente tincto papilloso coronato, ad 10 mmm. longis, basi rotundato, basi vel apice fortiter attenuato; ad septa non constrictis; episporio castaneo, 3–5 mmm. crasso, sparse rusticeque verrucoso; pedicello persistente, hyalino, apice tincto, crasso, ad 100 mmm. longis, 6–10 mmm. crasso, fistuloso, basi 18 mmm. inflato, verruculoso; foramine germinis ad cellulo 2–3, obscuro.

Hab.: In foliis vivis *Acaenae Sanguisorbae* Vahl. et *A. Sanguisorbae* Vahl. var. *pilosae* T. Kirk. Queenstown, Otago, New Zealand. 650 m. *W. D. Reid.*

4. **Milesina Histiopteridis** sp. nov. (Fig. 101.) Polypodiaceae.

II. Uredosoris hypophyllis, raris vel in linearis catervis, intercostalibus, ad 15 mm. longis, in maculis inaequalis discoloratis, 0·25–0·5 mm. latis, rotundis, bullatis, epidermide tectis, apicale aperto. Peridiis plano-globosis, ostiolatis, obovatis hyalinarum cellularum compositis, cellulo exteriore solide verruculoso. Uredosporis obovatis, ellipticis vel polygoniis, 18–26 × 14–18 mmm.; episporio hyalino, tenuiter verruculoso, 0·75–1 mmm. crasso, contentu hyalino, vacuolato; foraminis germinis obscuro.

III. Incognitis.

Hab.: In foliis vivis *Histiopteridis incisae* (Thunb.) J. Sm. Kelburn Wellington, New Zealand. *E. H. Atkinson, G. H. C.*

5. **Aecidium Celmisiae-discoloris** forma sp. nov. (Fig. 111.) Compositae.

0. Spermagoniis raris, sparsis, epiphyllis, immersis.

I. Aecidiis amphigeniis, praecipue epiphyllis, flavis, raris vel parvis catervis. Peridiis cylindricis, erumpentibus, super superficiem exstitis ad 1 mm., 0·1 mm. latis, marginibus incurvatis, primum dentatis demum profunde laceratis, albis. Aecidiosporis subglobosis, ellipticis vel obovatis, 36–42 × 28–34 mmm.; episporio hyalino, solide deciduis tuberculis tecto 3 mmm. crasso, contentu flavido, granuloso.

Hab.: In foliis vivis *Celmisiae discoloris* Hook. f., *C. Sinclairii* Hook. f., et *C. prorepentis* Petrie. Tooth Peaks, Otago, New Zealand. *W. D. Reid.*

6. **Aecidium Celmisiae-petiolatae** forma sp. nov. (Fig. 110.)

0. Incognitis.

I. Aecidiis hypophyllis, in maculis discoloris, raris vel parvis catervis, flavis. Peridiis plano-globosis, 0·25 mm. latis, immersis, marginibus incurvatis, hyalinis, tomento denso folii tectis. Aecidiosporis polygoniis,

ellipticis vel obovatis, 27–45 × 20–26 mmm.; episporio hyalino, solide subtiliter verruculoso, 1–1·5 mmm. crasso, contentu granuloso, luteo.

Hab.: In foliis vivis *Celmisiae petiolatae* Hook. f. Arthur's Pass, Canterbury, New Zealand, 1,000 m. *E. H. Atkinson.*

7. **Aecidium Celmisiae-Petriei** forma sp. nov. (Fig. 112.)

0. Spermagoniis sparsis, raris.

I. Aecidiis hypophyllis, in linearibus catervis, in maculis discoloratis, et bullatis infra tomentum folii diu tectis. Peridiis cylindricis, 0·25 mm. latis, tomento premente distortis, marginibus incurvatis, profundis laceratis, albis. Aecidiosporis longis-ellipticis vel obovatis-ellipticis, 36–52 × 20–25 mmm.; episporio hyalino, cum solide deciduo tuberculo tecto, 2 mmm. crasso, contentu granuloso, luteo.

Hab.: In foliis vivis *Celmisiae Petriei* Cheeseman. Lake Harris track, Otago, New Zealand, 1,100 m. *W. D. Reid.*

8. **Aecidium hupiro** forma sp. nov. (Fig. 109.) Rubiaceae.

0. Spermagoniis amphigeniis, immersis, ad aecidiis immixtis.

I. Aecidiis hypophyllis, in catervis inaequalibus, in maculis discoloratis luteis. Peridiis erumpentibus, cylindricis, 1 mm. altis, 0·5 mm. latis, marginibus erectis, non revolutis, laceratis, luteis. Aecidiosporis polygoniis vel ellipticis, 42–50 × 34–40 mmm.; episporio hyalino, solide rustice verruculoso, 2–2·5 mmm. crasso, contentu rustice granuloso, luteo.

Hab.: In foliis vivis et petiolibusque *Coprosmae foetidissimae* Forst. Alpha Hut, Mount Hector, Wellington, New Zealand, 1,700 m. *H. Hamilton, J. G. Myers.*

9. **Aecidium kowhai** forma sp. nov. (Fig. 104.) Leguminosae.

0. Incognitis.

I. Aecidiis caulicolis, in catervis longis, in tumerosis fusiformibus, ad 7 cm. longis, magnis fastigiatis distortionibus factis luteis. Peridiis cupulatis, breviter erumpentibus, 0·25 mm. altis, 0·5 mm. latis, pateris subtiliter revolutus, laceratis demum erosis, tinctis luteis. Aecidiosporis polygoniis vel ellipticis, 27–32 × 18–21 mmm.; episporio hyalino, solide subtiliter verruculoso, 1 mmm. crasso, contentu granuloso, luteo.

Hab.: In caulibusque *Edwardsiae tetrapterae* (J. Mill.) Oliver. Brightwater, Nelson, New Zealand, 200 m. *C. Nash, W. C. Hyde, G. H. C.*

10. **Aecidium Macrodontae** forma sp. nov. (Fig. 108.) Compositae.

0. Spermagoniis amphigeniis, praecipue epiphyllis, sparsis, aecidiis immixtis.

I. Aecidiis hypophyllis et petiolicolis, in catervis inaequalibus, ad 10 mm. longis, in maculis discoloratis distortionibus, luteis. Peridiis immersis, 0·1–0·2 mm. latis, marginibus incurvatis, dentatis. albis. Aecidiosporis polygoniis ellipticis vel obovatis, 25–37 × 18–24 mmm.; episporio hyalino, solide rustice verruculoso, 1 mmm. crasso, contentu luteo, granuloso.

Hab.: In foliis vivis et petiolibusque *Oleariae macrodontae* Baker. The track, Clinton Valley, Otago, New Zealand. *E. H. Atkinson.*

11. Aecidium Milleri forma sp. nov. (Fig. 105.) Tiliaceae.

0. Incognitis.

I. Aecidiis hypophyllis, in catervis minutisque raris, 3–6 in catervis, in maculis pallidis, luteis. Peridiis cupulatis, erumpentibus, 0·25 mm. latis, marginibus erectis, non revolutis, subtiliter dentatis, albis. Aecidiosporis subglobosis vel polygoniis, 20–26 × 17–23 mmm.; episporio hyalino, solide subtiliter verruculoso, 1 mmm. crasso, contentu luteo, vacuolato.

Hab.: In foliis vivis *Aristoteliae serratae* (Forst.) Oliver. Pokaka, Waimarino County, New Zealand, 800 m. *D. Miller.*

12. Aecidium Myopori forma sp. nov. (Fig. 106.) Myoporaceae.

0. Incognitis.

I. Aecidiis caulicoliis, truncicoliis et petiolicolis, in locis inflatis fusiformibus, ad 15 cm. longis, in catervis linearibus, aurantiacis. Peridiis erumpentibus, cylindricis, super superficiem exstitis ad 4 mm., 1 mm. latis, marginibus subtiliter expansis non revolutis, profunde inaequalibus laceratis, tinctis aurantiacis, demum albis. Aecidiosporis obovatis, ellipticis, polygoniis, raro lacrimiformibus, 21–45 × 17–20 mmm.; episporio hyalino, subtiliter solide verruculoso, 1 mmm. crasso, contentu rubescente-luteo, foramine germinis obscuro.

Hab.: In caulibusque, trunci, et petiolibusque *Myopori laeti* Forst. f. Palmerston North, Wellington, New Zealand, 250 m. *G. H. C.*

13. Uredo Crinitae forma sp. nov. (Fig. 114.) Gramineae.

II. Soris uredosporiferis amphigeniis, in maculis discoloratis, raris, raro confluentibus, ellipticis, 1 mm. longis, rubescente-aurantiacis, pulverulentibus, rupta epidermide cinctis. Uredosporis globosis vel subglobosis, 38–41 mmm. latis; episporio hyalino, solide subtiliter echinulato, 1 mmm. crasso, contentu aurantiaco, granuloso; foraminibus germinis raris, numerosis (12–18), conspicuis; numerosis hyalinis, capitatis paraphysibus immixtis.

Hab.: In foliis vivis *Dichelachnidis crinitae* (Forst. f.) Hook. f. Akaroa, Banks Peninsula, Canterbury, New Zealand. *W. D. Reid.*

14. Uredo karetu forma sp. nov. (Fig. 115.)

II. Soris uredosporiferis hypophyllis, in maculis fuscis, linearibus, raro confluentibus, pulverulentibus, 1 mm. longis, luteo-aurantiacis, rupta epidermide cinctis. Uredosporis subglobosis vel obovatis, 34–45 × 30–35 mmm.; episporio pallido-luteo, leniter subtiliter echinulato, 2–2·5 mmm. crasso, contentu luteo, granuloso; foraminibus germinis raris, numerosis (8–12), obscuris.

Hab.: In foliis vivis *Hierochloidis redolentis* (Forst. f.) R. Br. Sea-level, Bluff, Southland, New Zealand. *W. D. Reid.*

15. Uredo Phormii forma sp. nov. (Fig. 118.) Liliaceae.

II. Soris uredosporiferis hypophyllis, in maculis discoloratis, raris vel in catervis irregularibus, ellipticis, 1 mm. longis, aut confluentibus vel 6 mm. longis, ferrugineis, bullatis, pulverulentibus, rupta epidermide cinctis et partim tectis. Uredosporis obovatis, ellipticis vel subglobosis, 21–30 × 17–22 mmm.; episporio flavo-brunneo, rustice raro echinulato, 2·5–3 mmm. crasso, contentu brunneo, granuloso; foraminibus germinis raris, 3–5, communiter 3, conspicuis.

Hab.: In foliis vivis *Phormii tenacis* Forst. et *P. Colensoi* Hook. f. Tokaanu–Waiouru Road, Taupo, New Zealand, 800 m. *E. H. Atkinson.*

16. Uredo southlandicus forma sp. nov. (Fig. 122.) Compositae.

II. Soris uredosporiferis epiphylli, raris, rotundatis, 1 2 mm. latis, bullatis, flavo-brunneis, tectis. Uredosporis subglobosis vel ellipticis, 28–35 × 24–28 mmm.; episporio hyalino, rustice raro echinulato, 4–5 mmm. crasso, contentu granuloso, aurantiaco; foramine germinis non conspicuo.

Hab.: In foliis vivis *Oleariae angustifoliae* Hook. f. Sea-level, Bluff, Southland, New Zealand. *L. Cockayne.*

17. Uredo toetoe forma sp. nov. (Fig. 113.) Gramineae.

II. Soris uredosporiferis hypophyllis, raris, in maculis discoloratis, ellipticis, 0·5–1 mm. latis, aut confluentibus ad 4 mm. longis, rubro-brunneis. subtiliter dense echinulato, 1·5 – 2 mmm. crasso, contentu granuloso, brunneis; foramine germinis raris, 7–12, conspicuo, papillato.

Hab.: In foliis vivis *Arundinis conspicuae* Forst. f. Sandhills, Levin. Wellington, New Zealand, 16 m. *E. H. Atkinson, G. H. C.*

18. Uredo tupare forma sp. nov. (Fig. 123.)

II. Soris uredosporiferis hypophyllis, raris, in maculis pallidis, rotundatis, 1 mm. latis, aurantiacis, pulverulentibus, diu tomento folii tectis. Uredosporis obovatis vel ellipticis, 40 55 × 25–31 mmm.; episporio hyalino, dense minuteque echinulato, 1·5 – 2 mmm. crasso, contentu granuloso, luteo; foraminibus germinis raris, 6 8, obscuris.

Hab.: In foliis vivis *Oleariae Colensoi* Hook. f. Mount Waiopehu, Wellington, New Zealand, 1,700 m. *G. H. C.*

19. Uredo wharanui forma sp. nov. (Fig. 124.) Compositae.

II. Soris uredosporiferis hypophyllis, in maculis pallidis, rotundatis, 1 mm. latis, bullatis, rubro-aurantiacis, pulverulentibus diu tomento folii tectis. Uredosporis ellipticis vel obovatis, 35 55 × 26–34 mmm.; episporio hyalino, sparse rustice echinulato, 2 2·5 mmm. crasso, contentu granuloso, rubro-aurantiaco; foramine germinis non conspicuo.

Hab.: In foliis vivis *Oleariae insignis* Hook. f. Woodside Creek, Wharanui, Marlborough, New Zealand. *E. H. Atkinson.*

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COMBINED HOST AND FUNGUS INDEX.

Synonyms are in italics; families in small capitals. The page-number on which a description of a species, genus, or family occurs, or where a host of such a species is recorded, appears in italics; incidental references are in ordinary roman type; Latin diagnoses are in brackets. An asterisk preceding a page-number indicates that an illustration of the species in question will be found on that page.

A Revision of the New Zealand Nidulariales, or "Birds-nest Fungi."

By G. H. CUNNINGHAM, Mycologist, Biological Laboratory, Wellington, N.Z.

[*Read before the Wellington Philosophical Society, 23rd October, 1922; received by Editor, 31st December, 1922; issued separately, 26th May 1924.*]

Plates 3, 4.

ALL species belonging to this order are saprophytic, occurring on decaying wood, old sacking, or on the ground. They favour moist localities, and may commonly be found growing on humus on the forest-floor. The fructifications are quite small, seldom attaining a greater diameter than 10 mm.; they may be cup- or funnel-shaped, although frequently obconic forms occur.

The order is widely distributed, and some of the species have been found in nearly every country in the world; others, again, have a very limited distribution, occurring in but one or two localities.

The order comprises only one family, the Nidulariaceae, consisting of the four genera *Cyathus*, *Crucibulum*, *Nidula*, and *Nidularia*. The genus *Sphaerobolus*, at one time included in the Nidulariaceae, was by Ed. Fischer (1900, p. 346) placed in a separate family, the Sphaerobolaceae.

In structure the fructifications of all genera, *mutatis mutandis*, are essentially alike, a typical fructification consisting of a peridium containing numerous lenticular bodies, peridiola (also termed "sporangioles"), which in turn enclose the hymenium, consisting of basidia and paraphyses.

The peridium is typically campanulate, although obconic or infundibular forms occur. It consists of a single thick felt-like layer of closely woven hyphal filaments (in *Cyathus* it is composed of three layers). The apex is at first enclosed by a thin epiphragm (absent in *Nidularia*, the peridia of which are globose, and at maturity dehisce by the irregular rupture of the walls), which at maturity becomes ruptured and finally gelatinized. This membrane, in *Crucibulum*, is formed of the same tissue as the peridium, but in *Cyathus* is composed of the ungelatinized portion of the gleba, which at first is covered by the peridium; during development the peridial wall gradually becomes pulled away and the uppermost portion becomes exposed, appearing as a thin white membrane.

The peridiola are lenticular in shape, and in structure consist of an outer loosely woven covering of hyphae, the tunica (which in certain species of *Cyathus* may be very thin or wanting), enclosing a partly gelatinized layer, the cortex. This structure is closely compacted, the tissues forming a pseudoparenchyma which in mature specimens is hard and horny. Within the cortex is a loosely woven hyphal layer, the free surface of which constitutes the hymenium, and consists of basidia and paraphyses. These are arranged in an irregular palisade layer around a central cavity, which is usually filled with the spores. The basidia are tetrasporous, and the basidiospores are sessile, sterigmata being absent. During development the basidia and paraphyses become compressed, so that at maturity they appear as irregular angular tissues. The spores are binucleate, hyaline, and usually possess a thick epispore, enlosing granular contents. The peridium is at first filled with loosely woven hyphae; these later become gelatinized, when the peridiola lie embedded in a gelatinous matrix, the

gleba. When the epiphragm ruptures the gleba dries out, portion persisting as a delicate membrane lining the inner wall of the peridium. At maturity this membrane is quite smooth and shining, and is often mistaken for a layer of the wall of the peridium.

In *Cyathus* and *Crucibulum* the peridiola are attached to the inner wall of the peridium by fine thread-like filaments, termed "funiculi." In *Cyathus* the funiculus consists of a cord of interwoven hyphal filaments differentiated into three regions: (*a*) a solid cylinder whose distal end merges with the inner wall of the peridium, (*b*) a median constricted region, and (*c*) an upper hollow sheath connected basally with the constricted region and apically with the ventral surface of the peridiolum. Within this sheath is a delicate much-convoluted thread, attached by one end to the peridiolum, and by the other to the constricted portion. This thread, when moist, is capable of extension to a distance of several (5-8) centimetres.

In *Crucibulum* the funiculus is less complicated in structure, as the hollow sheath enclosing the convoluted thread early becomes gelatinized, and so at maturity the thread is embedded in the resultant mucilage.

Development (*Cyathus*).

From hyphae ramifying in the substratum, mycelial strands become differentiated; the terminal portions of these become enlarged, differentation of the basidiocarp commencing slightly below this region. In the region of the future inner wall of the peridium a zone of hyphae becomes gelatinized, the whole inner portion eventually forming the gleba, the external portion persisting as the wall of the peridium. Within this area, at the periphery, the peridiola become differentiated, each originating around a common centre toward which the ends of hyphal filaments converge, differentiation of peridiola occurring successively from the base of the developing peridium towards the apex. Then a layer of hyphae round each peridiolum becomes partly gelatinized and forms the pseudoparenchyma of the cortex.

The funiculus originates in somewhat parallel filaments extending from the innermost surface of the peridium to the peridiolum. Later appear actively growing hyphae which elongate rapidly and form a bundle of parallel filaments. Surrounding this certain hyphae gelatinize and form the outer sheath of the mature funiculus.

The peridium enlarges in size and becomes differentiated into three definite regions; differentiation occurs first at the base, new growth taking place in an apical peripheral zone, and as gelatinization occurs basally upwards the apical portion is the last to become gelatinized, and thus persists for some time as the epiphragm. Finally the peridium is drawn away from the apex and the epiphragm becomes exposed; this then ruptures and becomes gelatinized, the gleba becomes exposed, and as the moisture dries out the peridiola fall to the bottom of the peridium, remnants of the gelatinous gleba persisting as a thin lining on the inner surface of the peridium.

Thanks are due to Mr. C. G. Lloyd, Cincinnati, for the determination of two species; to Professor H. B. Kirk, Messrs. E. H. Atkinson, and R. Grimmett, Wellington, Miss H. K. Dalrymple, Dunedin, and Dr. K. M. Curtis, Nelson, for contributions of specimens; and to Messrs. E. Bruce Levy and W. D. Reid, of the Biological Laboratory, Wellington, for the photographs used in this paper.

NIDULARIACEAE.

Saprophytic plants, growing on decaying organic matter on the ground. Fructifications consisting of variously-shaped peridia, containing numerous indehiscent, compressed peridiola, in the interior of which are borne the hyaline, unicellular basidiospores.

Of the three genera which occur in New Zealand, *Cyathus* is represented by five species, *Crucibulum* by one, and *Nidula* by two.

KEY TO THE GENERA.

a. Peridiolum closed by a definite epiphragm.
 1. Peridiola attached by funiculi to the wall of the peridium.
  (*a.*) Peridium of three distinct layers; tunica thin or wanting .. .. 3. *Cyathus.*
  (*b.*) Peridium of one layer; tunica thick .. .. 2. *Crucibulum.*
 2. Peridiola unattached by funiculi but free within the peridium 1. *Nidula.*
b. Peridium dehiscing irregularly, epiphragm absent; peridium subglobose *Nidularia.*

I. NIDULA White.

White, *Bull. Torr. Cl.*, vol. 29, p. 271, 1902.

Peridium cyathiform, composed of a single thick and felted layer formed of coarse dingy-coloured hyphae; mouth covered by an epiphragm similar in structure and origin to that of *Cyathus*. *Peridiola* embedded in the gelatinous (when moist) gleba which fills the interior of the peridium, not attached by funiculi; similar in structure to those of *Cyathus*. *Spores* hyaline, binucleate; epispore thick.

Distribution.—North America; India; Japan; Australia; Ceylon.

This genus is separated from the two following because of the absence of a funiculus, the peridiola being free and embedded in the gelatinous gleba; when the epiphragm becomes ruptured the gleba dries out and the peridiola become free within the peridium. The wall of the peridium is similar in structure to that of *Crucibulum*, save that the filaments of which it is composed are pallid-white and not coloured.

1. Nidula candida (Peck) White. (Plate 3, figs. 1, 2*a*.)

White, *l.c.*, p. 271.

Nidularia candida Peck, *Reg. Rept.*, vol. 45, p. 24, 1891.

Peridia cyathiform, 6–15 mm. high, 6–15 mm. across the mouth, tapering slightly to the sessile truncate base, which is up to 8 mm. diam.; exterior white, becoming dingy with age, thick and felt-like, shaggy-tomentose, the tomentum aggregated into somewhat hispid tufts, interior smooth, shining, white or tinted yellow, darker below; mouth expanded but not recurved, entire, smooth, thick and firm. *Peridiola* reddish-brown, lenticular, 1·5–2 mm. diam., smooth; tunica thin, yellowish. *Spores* elliptical, 6–10 × 4–8 mmm.,* rounded at both ends.

Habitat.—Growing solitary on decaying wood and sticks on the ground.

Distribution.—Canada; Washington, North America: rare and local. Wallaceville, Wellington, *H. B. Kirk!* 24/7/21; Fringe Hill, Nelson, 500 m., *Miss K. M. Curtis!* 23/7/21.

The New Zealand form appears to be intermediate between this and the following species. For example, it has the solitary habit, large white

* In this article the contraction "mmm." is used for micromillimetres.

peridia covered with hispid tufts, and light-coloured peridiola of *N. candida*, and the smaller rugulose peridiola of *N. emodensis*. Then, too, the peridiola possess the peculiar stout, spiny, coloured fibrils so noticeable in the latter species, and the spores are roughly the same size; in shape, however, they are quite different. Nevertheless the peridal characters are so distinctive that I believe it should be retained under this species.

2. **Nidula emodensis** (Berk.) Lloyd. (Plate 3. figs. 2*b*, 3.)

Lloyd, *Nidulariaceae*, p. 12, 1906.

Cyathus emodensis Berk., *Hook. Jour. Bot.*, p. 204, 1854. *Crucibulum emodense* Berk., *Hdbk. N.Z. Fl.*, p. 621, 1867. *Nidula microcarpa* Peck; White in *Bull. Torr. Cl.*, vol. 29, p. 272, 1902. *Nidula microcarpa* var. *rugispora* White, *l.c.*

Peridia cyathiform, 4 6 mm. high, 4–5 mm. wide across the mouth, tapering slightly to the sessile truncate base, which is 3 5 mm. diam.; exterior dingy-grey, becoming darker with age, covered with closely appressed tomentum, wall much thinner than in the preceding species, interior smooth, shining, dingy-white, turning to pallid-brown in old specimens; mouth entire, slightly expanded, in old specimens slightly recurved, thin, smooth. *Peridiola* numerous, lenticular, reddish-brown, becoming almost black with age, 0·5–1 mm. diam., rugulose; tunica thick, fibrous, readily separable. *Spores* narrowly elliptical, or more commonly obovate or pyriform, apex rounded, base acuminate, 6–9 × 4 6 mmm.

Habitat.—Growing caespitose on decaying wood and sticks on the ground; rare.

Distribution. California, Montana, North America; Sikkim, India; Japan; Australia; Cambridge, Auckland, *G. H. C.*, 17/1/20; Nelson, *D. Munro.*

I am indebted to Mr. C. G. Lloyd for the determination of this species. He states that it possesses the same coloured fibrils in the tunica (the only character that separated *N. emodensis* from *N. microcarpa* Peck), and is therefore *N. emodensis*. These fibrils are thick, rigid, and dark-coloured, and possess numerous short spiny branches. They are known to occur only in this and the preceding species.

The caespitose habit, smaller smooth peridia, darker peridiola, and differently shaped spores separate this species from the preceding.

II. Crucibulum Tulasne.

Tul., *Ann. Sci. Nat.*, ser. iii, vol. 1, p. 89, 1844.

Peridium cyathiform, composed of a single thick felt-like membrane of closely woven coloured hyphae; mouth when young covered by a well-defined epiphragm, formed from the undifferentiated peridial wall. *Peridiola* numerous, each consisting of an outer thick loosely woven tunica, a thick horny dark-coloured cortex, and a loosely woven hymenial layer; attached to the peridial wall by a funiculus, which is more simple in structure than that of *Cyathus*. *Spores* hyaline, binucleate, epispore thin.

Distribution. -World-wide.

The genus is represented by a single species. It is separated from *Cyathus* on account of the peridial wall consisting of a single layer, and because of the more simple funiculus, and from *Nidula* on account of the presence of funiculi.

1. Crucibulum vulgare Tulasne. (Plate 4, figs. 4, 7.)

Tul., *l.c.*, p. 90.

* *Cyathus Crucibulum* Pers., *Syn. Fung.*, p. 238, 1801. *C. laevis* DC., *Fl. Fr.*, vol. 2, p. 269, 1805. *C. fimentarius* DC., *ibid.*, vol. 5, p. 104, 1815. *Nidularia Crucibulum* Secret., *Mycogr. Suisse*, vol. 3, p. 378, 1833. *N. juglandicola* Schw., *Trans. Am. Phil. Soc.*, vol. 4, p. 253, 1834. *Cyathus fimicola* Berk., *Linn. Jour.*, vol. 18, p. 387, 1881. *C. pezizoides* Berk., *l.c.* *C. pusio* Berk., *l.c.* *Crucibulum juglandicolum* De Toni in *Sacc. Syll. Fung.*, vol. 7, p. 44, 1888. *C. simile* Mass., *Grev.*, vol. 19, p. 94, 1891. *C. crucibuliforme* (Scop.) White, *Bull. Torr. Cl.*, vol. 20, p. 269, 1902.

Peridia cyathiform, up to 12 mm. high, 10 mm. wide at the mouth, tapering slightly to sessile truncate base, which may attain a thickness of 8 mm., seated on a basal pad of closely woven hyphae; exterior bright cinnamon, becoming dingy with age, in young specimens closely covered with silky appressed tomentum, becoming almost smooth with age, interior pallid-cinnamon, smooth, shining; mouth erect, or slightly expanded, margin even, thick, smooth. *Peridiola* pallid-brown or dingy-white, lenticular, smooth, 1·25–2 mm. diam.; tunica thick, dingy-white, readily separable. *Spores* narrowly elliptical, rounded at both ends, 7–10 × 4–6 mmm.

Habitat.—Growing solitary or caespitose on decaying leaves, sticks, old sacking, manure, &c., on the ground.

Distribution.—World-wide; common. Lake Papaetonga, Levin, *Mrs. M. Cunningham!* 31/8/19; York Bay, Wellington, *E. H. Atkinson!* 20/6/22; Cass, Canterbury, *unknown collector!* June, 1919; Fringe Hill, Nelson, 500 m., *Miss K. M. Curtis!* 23/7/21; Dannevirke, *W. Colenso;* Bay of Islands, *J. D. Hooker.*

This species varies considerably in the size and shape of the peridia and peridiola: for example, in specimens from the Cass the peridia are barely 5 mm. in height, and the peridiola correspondingly small, being less than 1 mm. in diameter.

III. CYATHUS Haller.

Hall., *Stirp. Helvet.*, vol. 3, p. 127, 1768. Ex Pers., *Syn. Meth. Fung.*, p. 237, 1801.

Cyathia P. Br., *Civ. & Nat. Hist. Jamaica*, p. 78, 1756.

Peridium composed of three distinct layers, at first closed by a thin white epiphragm which covers the mouth, dehiscing by the irregular rupture of this membrane. *Peridiola* lenticular, dark-coloured, consisting of an external white tunica which may be very thin or absent, a hard horny cortex, and an inner hymenial layer; attached to the inner wall of the peridium by a complex funiculus. *Basidiospores* hyaline, variable in size and shape, binucleate.

Distribution.—World-wide.

About twenty-six species are now recognized; of these five occur in New Zealand, one being endemic. The genus differs from *Crucibulum* in having a distinctly three-layered peridial wall, consisting of a loosely woven outer layer, a compacted pseudoparenchyma of partly gelatinized hyphal filaments forming a central layer, and an inner layer of loosely woven partly gelatinized filaments. It differs from *Nidula* in having the peridiola attached by funiculi to the inner wall of the peridium.

* For earlier synonymy see Tulasne (1844).

KEY TO SPECIES OF CYATHUS.

Peridia internally striate	1. *C. novae-zelandiae.*
Peridia internally smooth and even.	
Spores over 20 mmm. long	5. *C. stercoreus.*
Spores under 20 mmm. long.	
Peridiola 2–3·5 mm. diam	4. *C. Olla.*
Peridiola 2–2·5 mm. diam.	
Peridia cythiform ; margins erect	2. *C. Colensoi.*
Peridia campanulate ; margins flaring	3. *C. Hookeri.*

1. **Cyathus novae-zelandiae** Tulasne.

Tul., *Ann. Sci. Nat.*, ser. iii, vol. 1, p. 66, 1844.

Peridia infundibuliform, 12–14 mm. high, 5–7 mm. wide at the mouth, tapering gradually to the base where suddenly converging to a short stipe about 2 mm. long and 1 mm. thick; exterior dark brown, covered with appressed tomentum, interior longitudinally striate for about half the depth of the peridium, black, dull; mouth erect or slightly expanded, revolute, striate, margin entire, even. *Peridiola* lenticular, 2·3–3 mm. diam., black; tunica thin, white. *Spores* elliptical, somewhat pointed at both ends, 11–13 × 5–6 mmm.

Habitat.—Growing caespitose on rotting bark.

Distribution.—Banks Peninsula, Canterbury, N.Z.; rare.

Type specimens collected by Raoul.

This endemic species has been collected but once. It may readily be distinguished from any other species occurring in New Zealand by the presence of longitudinal striae on the upper portion of the peridium.

2. **Cyathus Colensoi** Berkeley. (Plate 4, fig. 2.)

Berk., *Fl. N.Z.*, vol. 2, p. 192, 1855.

Peridia campanulate, up to 7 mm. high, 6 mm. wide at the mouth, tapering abruptly to short and slender stipe which about 1 mm. diam.; exterior from pallid-grey to bay-brown, finely tomentose, even, interior lead-coloured, smooth, somewhat shining; mouth erect, in old specimens slightly recurved, margin entire, even. *Peridiola* lenticular, 2 mm. diam., black; tunica thin, white. *Spores* variable in shape and size, elliptical when 10–12 × 8–10 mmm., or subglobose when 9–12 mmm. diam.

Habitat.—Growing crowded or caespitose on dead wood on the ground.

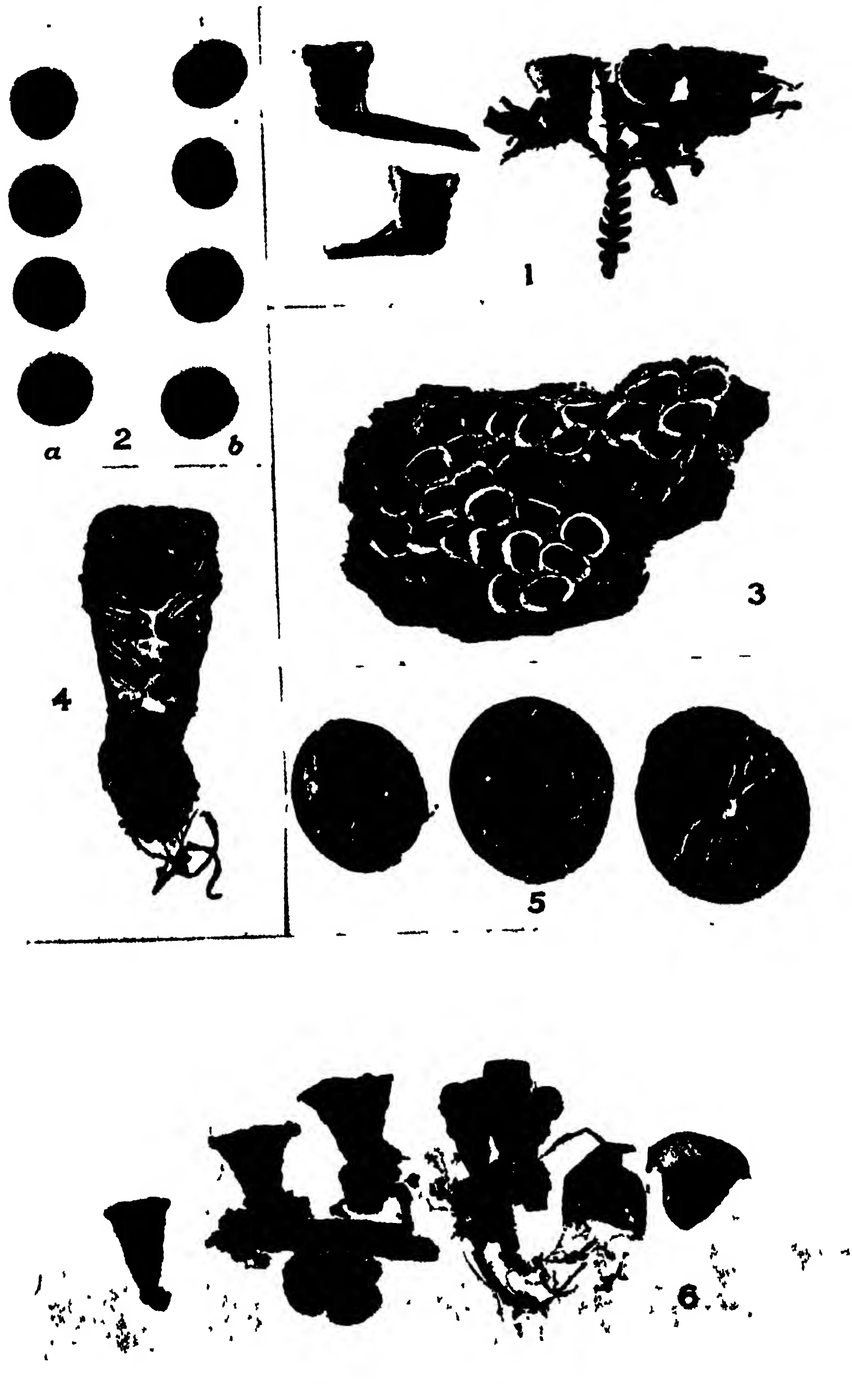
Distribution.—Australia; Dannevirke, N.Z.: rare. *W. Colenso*, Dannevirke (type), on ground in a garden.

This species somewhat resembles *C. Olla*, but may be distinguished by the smaller differently shaped peridia, smaller peridiola, and more globose

PLATE 3.

FIG. 1.—*Nidula candida* (Peck) White. Natural size. Epiphragm is present on the central plant. Section on the left; note the thick wall of the peridium.
FIG. 2.—*a.* Peridiola of *Nidula candida*; × 10 diam. *b.* Peridiola of *Nidula emodensis* (Berk.) Lloyd; × 10 diam.
FIG. 3.—*Nidula emodensis* (Berk.) Lloyd. Natural size. Plants are growing on rotting log of *Podocarpus* sp. Note the caespitose habit.
FIG. 4.—Section of young peridium of *Cyathus Olla* Pers., × 2·5 diam., showing the peridiola embedded in the gleba.
FIG. 5.—Peridiola of *Cyathus Olla* Pers. × 10 diam. Point of attachment of the funiculus shown on the specimen on the right.
FIG. 6.—*Cyathus Olla* Pers. Natural size. Immature plants in the centre, section of a peridium on the right.

(Fig. 4 photographed by the writer; all others by E. Bruce Levy.)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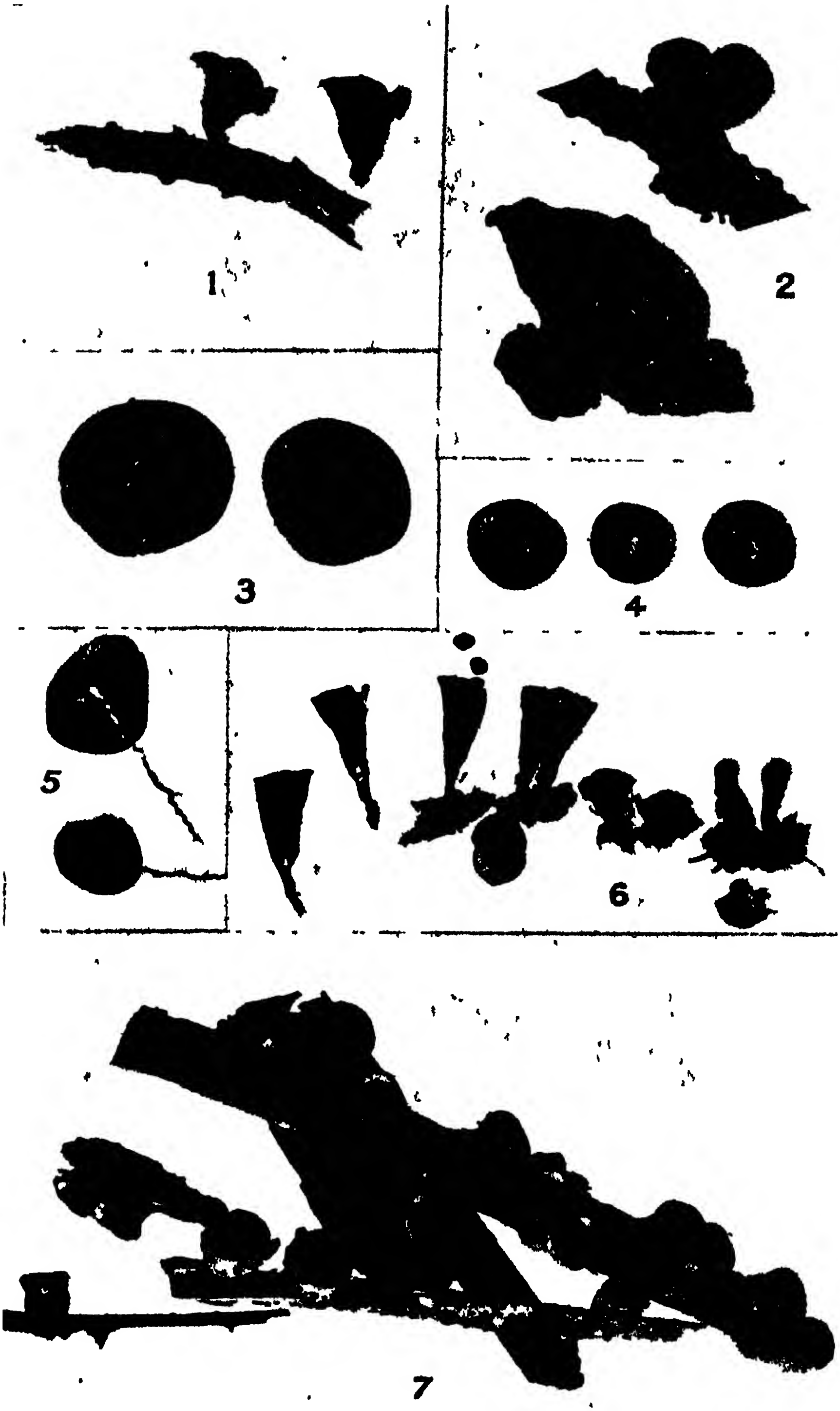

spores. I am indebted to Dr. J. B. Cleland, Adelaide, for the loan of specimens of this species. The photograph given is taken from his specimens.

3. **Cyathus Hookeri** Berkeley. (Plate 4, figs. 1, 3.)

Berk. in Hook. *Jour. Bot.*, p. 204, 1854.

Peridia campanulate, up to 14 mm. high, 10 mm. wide at the mouth, narrowing abruptly into a short stipe 2–3 mm. long, 2 mm. thick; exterior bay-brown, minutely and densely tomentose, interior even, dark brown, dull; mouth strongly expanded or flaring, margin entire, crenately lobed. *Peridiola* lenticular, 2–2·5 mm. diam., cortex black; tunica dingy-white, thin. *Spores* elliptical, rounded at both ends, 8–11 × 6–8 mmm.

Habitat.—Growing solitary or caespitose on decaying twigs, &c., on the ground.

Distribution.—Khasa, India; North Island, N.Z.: rare. Weraroa, Wellington, on rotting twigs of *Pinus* sp., *G. H. C.*, 18/8/19.

I am indebted to Mr. C. G. Lloyd for the determination of this species. In a recent letter he stated that he did not consider it to be sufficiently distinct from *C. microsporus* Tul. to be maintained as a distinct species. I am of the opinion, however, that the large campanulate peridium and larger spores are sufficient to maintain it as a valid species.

4. **Cyathus Olla** Persoon. (Plate 3, figs. 4, 6.)

Pers., *Syn. Meth. Fung.*, p. 237, 1801.

Cyathus vernicosus DC., *Fl. Fr.*, vol. 2, p. 270, 1805. *Nidularia plumbea* Pers., *Champ. Comest.*, p. 110, 1818. *N. fasciculata* Schw., *Trans. Am. Phil. Soc.*, vol. 4, p. 253, 1834. *Cyathus campanulatus* Cda., *Anleit.*, lxxx, pp. 19–23, 1842. *C. similis* Cke., *Grev.*, vol. 8, p. 58, 1879. *Cyathia lentifera* (L.) White, *Bull. Torr. Cl.*, vol. 29, p. 264, 1902.

Peridia at first urceolate, becoming campanulate, up to 15 mm. high, 6–12 mm. wide at mouth, tapering strongly to the sessile truncate base; exterior grey-fawn, bleaching pallid-yellow with age, clothed with fine appressed tomentum, interior smooth or somewhat concentrically zoned, dull lead-colour, shining; mouth strongly expanded or flaring, not or slightly recurved, margin entire, crenate. *Peridiola* lenticular, dark brown or lead-coloured, large, 2–3·5 mm. diam., smooth, or minutely rugulose when dry; tunica thin, dingy-white, closely adnate. *Spores* obovate or elliptical, 8–15 × 6–10 mmm., apex rounded, base bluntly pointed.

PLATE 4.

FIG. 1.—*Cyathus Hookeri* Berk. Natural size.

FIG. 2.—*Cyathus Colensoi* Berk. × 2 diam. Immature plants at the top. Photos taken from Australian specimens loaned by Dr. J. B. Cleland.

FIG. 3.—Peridiola of *Cyathus Hookeri* Berk. × 10 diam. The depression in the surface of the specimen on the right shows point of attachment of the funiculus.

FIG. 4.—Peridiola of *Crucibulum vulgare* Tul. × 10 diam.

FIG. 5.—Peridiola of *Cyathus stercoreus* (Schw.) de Toni. × 10 diam. Note the extended funiculi.

FIG. 6.—*Cyathus stercoreus* (Schw.) de Toni. Natural size. Immature specimens on the right; small form in the centre.

FIG. 7.—*Crucibulum vulgare* Tul. Natural size. The epighragm is present on several of these specimens.

(Fig. 2 photographed by the writer; all others by E. Bruce Levy.)

Habitat.—Growing solitary or caespitose on rotting twigs, dead grass-stems, or on the ground.

Distribution.—World-wide; common. Pukeora, Hawke's Bay, *H. E. Radcliffe!* 17/10/21; Wellington, *R. Grimmett!* April, 1922; Dunedin, *Miss H. K. Dalrymple!* 5/5/22; Kelburn, Wellington, *G. H. C.*, April, May, 1922.

The large, smooth, campanulate peridia and large peridiola characterize this species. The peridia are often concentrically zoned, and vary greatly in size. This is our most common species of *Cyathus.*

5. **Cyathus stercoreus** (Schw.) De Toni. (Plate 4, figs. 5, 6.)

De Toni in *Sacc. Syll. Fung.*, vol. 7, p. 40, 1888.

Nidularia stercorea Schw., *Trans. Am. Phil. Soc.*, vol. 4, p. 253, 1834. *N. melanosperma* Schw., *l.c. Cyathus Lesueurii* Tul., *Ann. Sci. Nat.*, ser. iii, vol. 1, p. 79, 1844. *C. Wrightii* Berk., *Grev.*, vol. 2, p. 34, 1873. *C. melanospermus* De Toni in *Sacc. Syll. Fung.*, vol. 7, p. 42, 1888. *C. Baileyi* Mass., *Grev.*, vol. 21, p. 3, 1892. *C. dimorphus* Cobb, *Agr. Gaz. N.S.W.*, p. 1005, 1892. *C. affinis* Pat., *Bull. Soc. Myc. Fr.*, p. 87, 1895. *C. rufipes* Ell. et Ev., *Bull. Torr. Cl.*, vol. 24, p. 125, 1897. *Cyathia melanosperma* (Schw.) White, *ibid.*, vol. 29, p. 262, 1902. *C. rufipes* (Ell. et Ev.) White, *l.c.*, p. 265. *C. Wrightii* (Berk.) White, *l.c.* *C. stercorea* (Schw.) White, *l.c.*, p. 266.

Peridia at first urceolate, becoming obconic or campanulate, 5–15 mm. high, 4–8 mm. across the mouth, tapering gradually to the slender and short stipe, or sessile; exterior fawn-coloured, at first hirsute, becoming almost smooth with age, interior smooth, lead-coloured, shining; mouth erect, not or slightly expanded, margin entire, even. *Peridiola* lenticular, 2 mm. diam., smooth and shining, black; tunica wanting. *Spores* subglobose, 20–40 mmm. diam.; epispore 3 mmm. thick.

Habitat.—Growing solitary or caespitose on manure, decaying wood, soil, and boxes in glasshouses, &c.

Distribution.—World-wide; common. Mapua, Nelson, on cow-dung, *G. H. C.*, 17/5/22.

This species varies considerably in the size and shape of the peridia. It may readily be separated from other species of this genus on account of the large-sized spores, black peridiola, and narrow obconic peridia. Lloyd (1906, p. 20) states that peridia are occasionally found in which the upper peridiola are not attached to the wall by funiculi, this latter structure apparently being rudimentary or absent. He also mentions the fact that with this species sterile peridiola commonly occur, a feature apparently not uncommon in the large-spored species.

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Studies in the New Zealand Hymenophyllaceae: Part 2—The Distribution of the Species throughout the New Zealand Biological Region.

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CONTENTS.

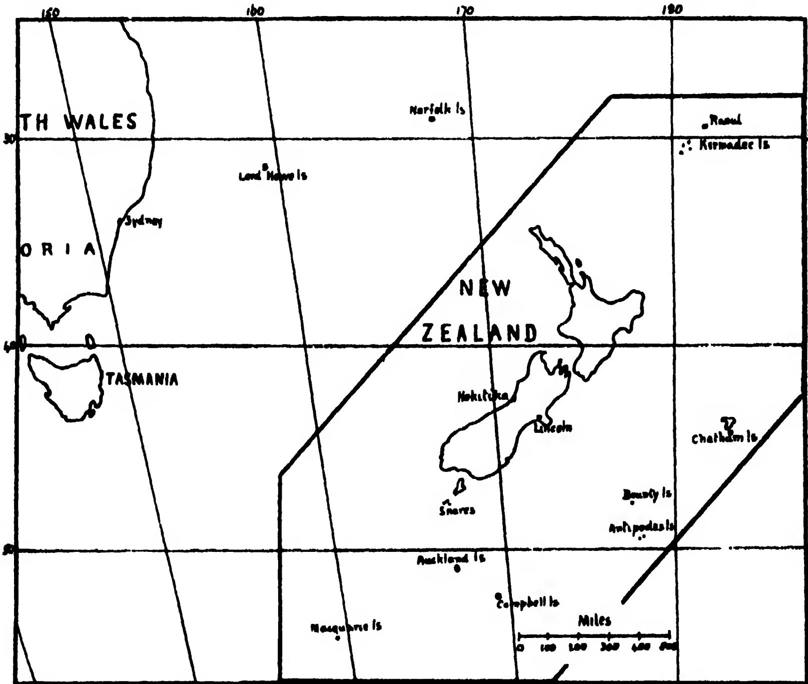
INTRODUCTORY.

In a previous paper (18) I have given an account of my observations in the wet district of Westland on the distribution and growth-forms of the species of the New Zealand fern-genera *Hymenophyllum* and *Trichomanes*, including in it, from observations made in other parts of New Zealand, an account of the three species which apparently do not occur in Westland. Since the species occur at their optimum development in the humid forests and mountain ravines of Westland, the above-mentioned account will serve as a standard for comparison with ecological data concerning this fern-family gathered in other and drier districts of the New Zealand Biological Region.

In a well-known paper, entitled "The Geographical Distribution of Ferns," published in the *Transactions of the Linnean Society* in 1868, J. G. Baker observed that "with the precision of an hygrometer, an increase in the fern vegetation (it may be in species, or it may be in the number and luxuriance of individuals, but usually in both) marks the wooded humid regions." The filmy ferns, being as a family specially adapted to humid conditions, respond very quickly in their manner of distribution, and, in the case of many of the species, in their growth-forms also, to variations in the atmospheric humidity, as was shown in my paper quoted above. The species of this family, then, will undoubtedly serve as indicators of the climate of the forest-interior of any particular locality, and the indications will be found not only in the presence or absence of individual species, their comparative abundance and luxuriance, and in the growth-forms adopted by them, but also in the exact station taken up by them in the forest. In the present paper I propose to trace the distribution of the family more especially in the comparatively dry Eastern

Botanical District of the South Island of New Zealand (see map 4, p. 85), and to bring together the facts concerning their occurrence in the remaining parts of New Zealand and in the outlying islands which I have gathered from my own observations or are contained in various botanical papers in the *Transactions of the New Zealand Institute* and in other scientific publications.

The only really satisfactory meteorological data for use in such a study as the present one would be those recording the range in humidity in the forest-interior from day to day and from season to season, so that in this way a close comparison might be instituted between different types of forest and between different stations in the forest under varying conditions of climate and altitude, with a view to ascertaining both the minimum and the optimum



MAP 1. The New Zealand Biological Region.

degree of humidity for each species. A large yearly rainfall might be found to characterize some locality which experiences an annual dry season, and under these conditions the filmy-fern flora would be scanty and local, there would be few epiphytes in the forest, and in a general way the forest-floor would be bare of all but the hardiest ferns. Even if there were no specially dry season in the year, extreme temporary fluctuations in the humidity– due, for example, to dry winds– would largely determine in any locality the distribution and growth-forms of the Hymenophyllaceae. Thus meteorological data to be of use by themselves in such a study as the present should be detailed, for it is evident that the Hymenophyllaceae for the most part need not only a high but a continuously high atmospheric humidity. It would be manifestly impossible to collect detailed data of this kind over so extended and varied a region as I am here dealing with,

so that I have had to fall back upon such evidence as is afforded by the actual rainfall data, supplemented by general climatic information, and by the study of the general fern and other forest vegetation present.

For a detailed list of the twenty-six New Zealand species reference must be made to my previous paper (18) and to the *Manual of the New Zealand Flora* (10). I take this opportunity of acknowledging the source of the rainfall map on page 73, which I have adapted from that issued by the Government Meteorological Office, and of the meteorological data, which I have culled from the regular publications of the Department; and also of L. Cockayne's map on page 85, which I have taken from his paper (14) on the proposed botanical districts of New Zealand.

1. THE CLIMATE, FOREST-COVERING, AND DISTRIBUTION OF THE HYMENOPHYLLACEAE EAST OF THE SOUTHERN ALPS.

From the meteorological data set out in Table A, on page 70, it is evident that the climate experienced at the east coast of the South Island is very different from that at the west. The total number of rainy days at Lincoln is only about three-fifths of that at Hokitika, and the rainfall is less than a quarter as much. This difference is reflected also in the greater number of hours of sunshine at the former than at the latter station. The most important climatic fact of all, however, is one that does not appear in the table namely, that there is an almost complete absence of strong dry winds in Westland, at any rate so far as the lowlands are concerned, whereas in Canterbury the excessively dry and often fierce north-west wind is a characteristic, if intermittent, feature. The fact that Hokitika lies in the path of the prevailing westerly moisture-laden winds is accountable for the greater average daily wind-velocity recorded here than at Lincoln. It will be seen also that not only is the mean humidity noticeably less for Lincoln than for Hokitika, but the seasonal variation is more marked. Finally, the daily and also the seasonal range in temperature is less at Hokitika than at Lincoln. Humidity data, perhaps more than any other, need to be qualified with a statement as to the particular conditions under which they are taken. All the data given in Table A were taken in the open, and do not, of course, refer to actual forest conditions. However, they enable us to gain a good idea as to what those conditions will be. The lack of drying winds, the low summer temperature, the heavy rainfall, and large number of rainy days fairly evenly distributed over the whole year all point to the fact that in the Westland forests the humidity is more or less constantly high, and that transpiration from frond and leaf-surface will probably never be excessive. On the other hand, in Canterbury the strong dry winds will bring about such extreme fluctuations in the humidity that they may be regarded as one of the most important factors in the determination of the plant-covering. In the forest-interior also these fluctuations will be felt, and the fern flora and the station adopted by the individual species will be restricted thereby. The other climatic factors also will tend to make the atmospheric humidity in the Canterbury forests both lower and also more variable than in those of Westland, such as the very much smaller rainfall, the greater amount of bright sunshine, the hotter summer and the colder winter, and the greater daily range in temperature. From these facts it would follow that the forests of Canterbury would be less extensive than and different in type from those of Westland, and that the distribution in them of the Hymenophyllaceae and other fern-families would be more restricted.

TABLE A.

Meterological Data for Hokitika and Lincoln, situated on the West and East Coasts respectively of the South Island, New Zealand, giving the Means for the Period 1911–20 inclusive.

—	January.	February	March	April	May	June	July.	August	September	October.	November	December	Year
Rainfall, in inches—													
Hokitika	10·44	6·60	8·22	10·61	8·09	8·29	8·90	9·05	11·07	12·04	17·76	8·79	114·86
Lincoln	2·58	2·14	1·32	2·04	2·43	2·35	2·95	1·47	2·07	1·61	1·93	2·30	25·19
Rainy days—													
Hokitika	16·7	11·2	14·1	17·7	14·7	17·0	16·4	15·7	19·8	19·7	21·6	15·3	199·9
Lincoln .. .	9·6	8·2	8·3	9·6	11·3	12·1	12·3	10·6	10·0	9·8	12·5	10·1	124·4
Mean humidity—													
Hokitika	77·0	77·6	76·5	76·3	73·2	75·9	73·1	72·9	75·5	77·7	79·6	79·5	76·3
Lincoln	68·2	70·8	69·3	71·9	74·5	76·5	76·7	74·9	71·6	69·6	69·5	68·2	71·7
Average daily velocity of wind, in miles—													
Hokitika (1911–19) ..	139·8	115·7	103·0	103·8	87·3	87·2	87·2	97·7	147·8	168·3	175·7	159·2	122·7
Lincoln	148·1	125·5	120·0	100·0	89·2	84·9	84·1	96·6	116·0	135·6	138·3	141·8	114·4
Sunshine, in hours and minutes—													
Hokitika (1913-20) .	192 24	177 26	177 27	130 37	141 55	101 44	109 20	153 32	135 26	162 6	171 36	217 41	1871 14
Lincoln .. .	217 85	188 12	197 5	152 45	137 55	113 40	124 73	153 50	176 5	218 5	208 32	213 65	2103 52
Shade temperature—													
Hokitika—													
Mean maximum ..	65·5	66·9	65·9	61·5	56·4	52·7	53·3	54·4	56·8	58·8	59·9	62·9	59·6
Mean minimum ..	51·5	52·6	51·1	47·5	40·3	38·2	37·6	37·9	42·6	45·4	47·0	49·1	45·0
Lincoln—													
Mean maximum ..	72·5	71·1	69·4	64·7	65·8	53·0	52·0	54·0	59·3	64·5	66·6	69·5	63·5
Mean minimum ..	50·6	54·4	49·3	44·7	39·3	36·2	36·0	36·6	40·5	43·8	45·7	47·5	43·7

With regard to the forest-covering, it may be said generally that there is but the one type in Westland—namely, the very heavy mixed taxad rain forest. It is true that there are variations in this, such as the more open black-pine and white-pine stands of the river-flats, and the characteristic association of the higher mountain-flanks; but these can be regarded here as local varieties of the taxad rain forest. East of the dividing range, however, there is a considerable differentiation in the forest-covering, depending both upon altitude and upon general climatic conditions. The relation between the forest type and the soil-conditions cannot be entered into here. In Canterbury there is both rain forest and also dry southern-beech forest. On the eastern flanks of the dividing range the altitudinal factor is the stronger, and, although the rainfall is heavy, the rain forest is not taxed but mountain southern-beech. Cockayne and Laing have shown, however (16, p. 363), that at the source of the Rakaia River, on the eastern flanks of the main ranges, the mountain-totara and the kawaka form a very characteristic association which can be regarded as true western rain forest. I have preferred to consider the occurrence of the Hymenophyllaceae in this southern-beech rain forest apart from their occurrence in the Westland forests, although these two types of forest as they here occur belong to the same botanical district of L. Cockayne (14), and I have done this in order to reduce the problem of their distribution in Westland as far as possible to the simple question of the effect upon the family of altitude alone. In South Canterbury the outlying areas of rain forest lie at a lower altitude and are not southern-beech, but mixed taxads. On account of the moderate rainfall, however, they are less heavy than those of Westland, and lack a number of characteristic members of the Westland rain forest. In North Canterbury, where the north-west wind is most experienced, the dry southern-beech forest prevails, although this dry wind, of course, may not be the only cause determining its presence. Thus whereas in Westland the regional distribution of the Hymenophyllaceae is dependent, on the whole, upon the altitudinal factor alone, east of the dividing range there must be considered, in addition to the altitude, the type of forest present, and also the particular rainfall and general humidity conditions prevailing in each area of forest.

Table A, indicating the difference in the climate experienced at the west and east coasts respectively, is taken from Part I of these Studies.

A. *The Eastern Flanks of the Southern Alps.*

In my previous paper I have given a detailed account of the occurrence of the Hymenophyllaceae in the Otira Gorge and on the neighbouring mountain-sides at the western extremity of Arthur's Pass. I will now trace their distribution on the eastern side of the pass and on the eastern flanks of the dividing range in its vicinity (see maps on pages 73 and 76).

The rainfall at the eastern portal of the Midland Railway tunnel which pierces the range at this point, distant a little over five miles from the western (or Otira) portal, is somewhat less than that recorded for the latter locality. As at Otira, the main continuous rain comes from the north-west. In accordance with its higher altitude (viz., 2,435 ft.), more snow falls in winter at the eastern end of the pass than at the western (1,583 ft.). The rainfall diminishes rapidly farther down the Bealey River valley which descends from the pass in a south-easterly direction, and at the junction of the Bealey with the main Waimakariri River valley, and in this

latter valley itself, the north-west rain is experienced for the most part only as heavy intermittent showers. Table B gives the rainfall in inches and the number of rainy days at Otira, at the eastern portal of the tunnel, and at the Bealey accommodation-house respectively, for each month of the year 1914, from which a good idea can be gathered as to the diminishing of the rainfall eastwards. The Bealey accommodation-house is situated on the east side of the Waimakariri River at a distance of two miles from where the Bealey Valley opens out into the latter, and of twelve miles as the crow flies south-east of Otira, and at an altitude of about 2,000 ft. It lies just beyond the limit of the rain forest.

TABLE B.

Year, 1914.

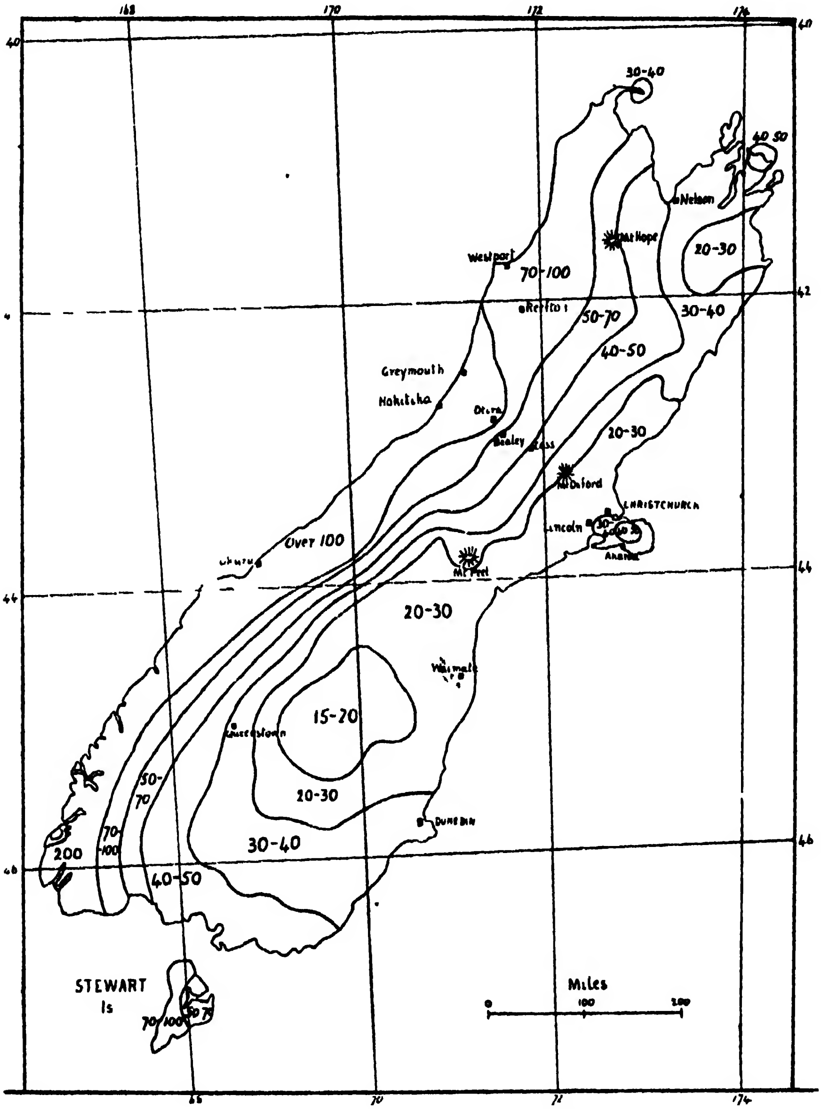
—	Jan.	Feb.	Mar.	April	May	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Otira.													
Rainfall ..	19·44	7·63	4·05	25·67	15·08	7·96	10·50	12·03	17·99	12·31	24·14	36·09	192·89
Rainy days..	23	10	12	24	12	15	17	16	16	17	20	22	204
Eastern Portal of Tunnel.													
Rainfall ..	16·58	6·47	2·60	25·12	12·51	6·82	7·29	8·59	13·64	10·01	19·13	26·85	155·61
Rainy days..	20	9	12	23	12	15	14	12	14	15	16	20	182
Bealey.													
Rainfall ..	5·80	2·05	4·09	6·91	5·27	1·15	3·90	4·37	4·92	3·82	6·86	8·55	57·69
Rainy days..	12	8	7	9	–	4	9	10	5	10	13	13	100*

* 11 months.

It may be added that the mean annual totals for these three stations for the period 1912–15 were as follows: Otira, 202·99 in. on 197·7 days; eastern portal, 174·80 in. on 193·2 days (March, 1915, omitted); Bealey, 67·40 in. on 115 days (May, 1914, omitted).

On the eastern flanks of the main range there is a continuous clothing of forest which consists practically solely of the mountain southern-beech (*Nothofagus cliffortioides*). The three characteristic tree-members of the Westland mountain forests—viz., the southern rata (*Metrosideros lucida*), the kawaka (*Libocedrus Bidwillii*), and the mountain-totara (*Podocarpus Hallii*)—are practically absent, although they occur somewhat scantily along with their seedlings and saplings amongst the *Nothofagus* on the eastern side of Arthur's Pass. The fact that the mountain-totara - kawaka association is found only in certain specially favourable localities on the eastern flanks of the divide (as noted above) must be taken as due primarily to a marked difference in the climate between west and east. The undergrowth of the southern-beech forests consists for the most part of the *Nothofagus* seedlings and saplings, although such large-leafed shrubs as *Nothopanax Colensoi*, *N. simplex*, *Phyllocladus alpinus*, *Griselinia littoralis*, &c., enter sparsely into its composition, more especially in the smaller gullies. The canopy of this *Nothofagus* forest is more or less open on account of the twiggy nature of the branches and the very small size of the leaves, and in considering its fern content the restrictive effect of this feature must be added to that of the climate generally. Moreover, the tree-trunk bases are for the most part regularly cylindrical and erect, and of small diameter, and accordingly do not provide the favourable stations for low epiphytes as

do the overhanging and irregularly growing large tree-bases of the southern rata and the mountain-totara. In spite of the heavy annual rainfall the floor of the forest is frequently dry, and on one occasion on which the writer examined the Bealey Valley forest it was noticeable how remarkably rapidly the forest-floor and the trees generally had become dry after two



MAP 2.—Rainfall map of South Island of New Zealand.

or three days of rain and snow, in spite of the fact that there had been no wind. In view of this it is not surprising that another prominent characteristic of the Westland forests is here absent—namely, the constant clothing of the boulders and fallen logs with ferns and liverworts.

Throughout this eastern mountain rain-forest *Hymenophyllum villosum* is fairly abundant both in moss on the floor and as a low epiphyte, the only other epiphyte being the small hardy *Polypodium Billardieri*, which also keeps to within a very few feet of the ground. *H. multifidum*, *H. flabellatum*, and *H. rarum* are also present, though much less commonly, and always on shaded rock-faces or in other overhung places, the two latter species in small stunted colonies. The only other ferns to be met with are the hardy and widespread *Polystichum vestitum*, *Blechnum penna marina*, and *B. vulcanicum* (these three being abundant), such rupestral species of *Asplenium* as are widespread throughout the drier parts of the South Island, and also the mountain *A. trichomanes*, although in damp gullies and hollows *Blechnum capense*, *Gleichenia Cunninghamii*, and *Asplenium bulbiferum* are not uncommon. It is noticeable that *Hymenophyllum demissum* and *H. bivalve*, which are frequent terrestrial or low epiphytic species in the western mountain forests, and are also most abundant in the southern-beech forests of Nelson up to an altitude of 3,000 ft., are here apparently altogether absent, although Armstrong (5) reported finding the former. Thus only those Hymenophyllaceae are present which in Westland were found to be able to adopt the high epiphytic station and the close mat growth-form, and of these only *H. villosum*, the hardiest species in the New Zealand family, is at all frequent.

On damp, moss-covered rock-faces in the forests of rather lower altitudes I have also occasionally found *H. pulcherrimum* and *H. peltatum*. These two species in Westland belong to the mountain ravines and do not descend to the lowlands. They are neither, however, especially hygrophilous, and *H. peltatum* is also a typical mat-former. Throughout the forests of the Eastern Botanical District the latter must certainly be included among the very few species which are at all abundant.

In addition to the Hymenophyllaceae enumerated above as occurring on the eastern flanks of the main divide, *H. Armstrongii* was originally discovered (4) alongside waterfalls near the source of the Waimakariri River at an altitude of 3,800 ft., and probably exists elsewhere also in similar localities. *H. Malingii* occurs almost invariably on old large trunks of the kawaka, and it has been reported from the kawaka forest noted above as occurring at the head of the Rakaia River. The peculiar frond-form of this species, as noted in my first paper (18), is well adapted to withstand drying.

B. *The Intermediate Montane Area.*

The neighbourhood of Cass (see maps on pages 73 and 76), which is situated on the Midland Railway at an altitude of 1,850 ft., may be taken as representing more or less typically those montane tussock-grasslands of Canterbury which lie between the dividing range and the more easterly outlying mountains. Through the kindness of Dr. C. Chilton, Professor of Biology at Canterbury College, I was able to stay for a few days at the College Biological Station at Cass, and from this as my centre to examine the neighbouring country, and also the forests of the Waimakariri Valley. I desire to express my thanks to Dr. Chilton for the opportunity thus given me, and also to Mr. C. E. Foweraker, of the Biological Laboratory, who accompanied me on these expeditions.

There is a rain-gauge at the Biological Station, which is read at intervals, and from the data thus gathered it seems clear that the rainfall is here somewhat less than at Bealey, which lies about six miles due west. The north-west showers frequently pass down the Waimakariri Valley, and so do not reach Cass, which lies two miles up a lateral valley. The

north-west winds, however, are frequent and drying, and at times very fierce. It is apparent, then, that Cass possesses a more severe climate than that which prevails on the eastern flanks of the dividing range. Cockayne and Laing have shown (16, p. 345) that these two climates, the subalpine forest and the tussock-grassland climate, pass into one another without a transitional phase, and that the sharply defined line which separates them extends throughout Canterbury at a short distance east of the dividing range. They add, "The steppe [*i.e.*, the tussock-grassland] climate is far from being really dry, but clear skies with strong insolation are frequent, and the ever-present wind would demand a much higher rainfall before forest could establish itself naturally." The following are the annual rainfall figures available with respect to Cass: 1917 (from 21st April), 38·7 in.; 1918, 59·8 in.; 1919, 40·6 in.; 1920, 43·0 in.

In accordance with these climatic conditions the southern-beech (*N. cliffortioides*) forest in the neighbourhood of Cass is present only in patches in the mountain-side gullies, the greater part of the area being covered by tussock-grass, divaricating shrubs, and subalpine herbs, and the river-terraces by mat and cushion plants and by the thorny *Discaria toumatou*. For a fuller account of the plant ecology of this area reference must be made to Cockayne and Foweraker (15). The interior of the patches of *Nothofagus* forest is very open and dry, and there are few shrubs. The few hardy ferns are more or less confined to the immediate neighbourhood of the watercourses, and epiphytes are altogether lacking. The only species of *Hymenophyllum* present is *H. villosum*, which occurs on the ground in moss near the creek-sides. Mr. Foweraker informs me that the same species is present in a very stunted form on rocks at the summit of Mount Sugarloaf, in the immediate vicinity of Cass, at an altitude of about 4,000 ft.

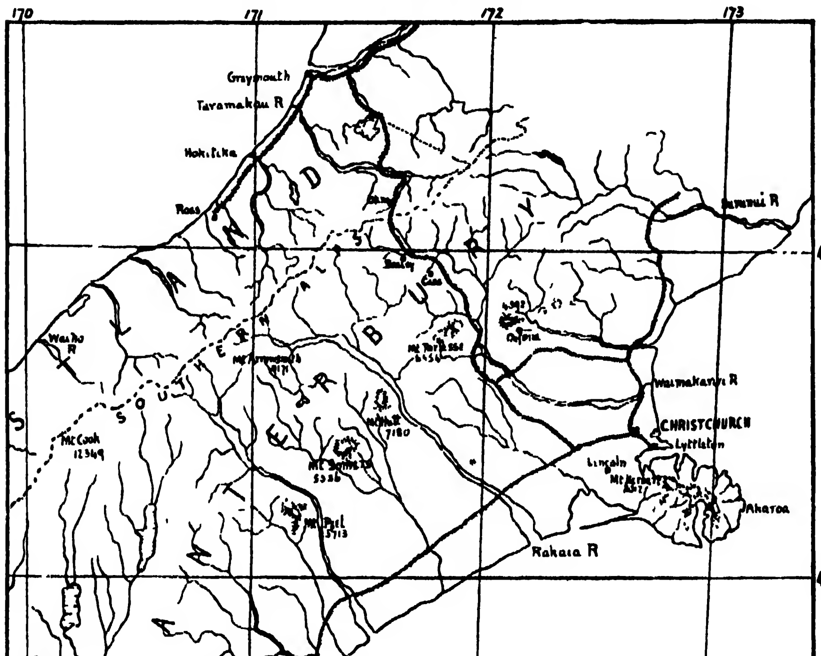
In their account of the plant ecology of the Mount Arrowsmith district (see map 3, on page 76), which lies between the upper Ashburton and Rakaia Rivers, a few miles to the east of the boundary of the Western Botanical District, Cockayne and Laing (16, p. 357) note the presence at subalpine altitudes of *H. villosum* as a special rock-plant, and *H. multifidum* on peaty humus on rock-ledges and in chinks. Dr. Cockayne informs me that on the wetter mountains of Central Otago (see map 4, on page 85) *H. multifidum* occurs in its mountain form in sheets on shady rocks at altitudes of 3,000 ft. and upwards.

C. *The Eastern Outlying Mountains of Canterbury.*

From map 3, on page 76, it will readily be seen that separating the intermediate montane area of Canterbury from the eastern plains there is a chain of high outliers, separated from one another by the main river-valleys. These outliers are forest-clad on their seaward slopes. I propose now to give a description of the distribution of the Hymenophyllaceae in the forests of three of these outliers—viz., Mount Oxford in the north, Mount Peel and Mount Studholme in the south—adding also what is known as to their occurrence in the original forests of Banks Peninsula.

As has already been mentioned, the presence of continuous forest on the eastward slopes of these outliers, which in the case of South Canterbury, and also of Banks Peninsula, must be reckoned rain forest, is due to the easterly and south-westerly precipitation in addition to the occasional north-west showers. The fierce and drying nature of the north-west winds is experienced rather in the northern than in the extreme southern parts of Canterbury. I am informed by Mr. F. Akhurst, the meteorological

observer at Waimate, that there the prevailing winds are light east and north-east, with light rain, the heaviest rains coming from the south-west; while the north-west winds only very occasionally pass beyond the interior, and even then have lost their violence. At Mount Peel also the greater part of the rainfall is derived from the south-west, although here the north-west winds sometimes bring heavy showers. On Mount Torlesse and Mount Oxford and farther north there is less of the steady south-west rain and more of the north-west showers, and the significance of this lies



Map 3.—Canterbury, N.Z., showing outlying mountains.

in the fact that the latter, being accompanied by heavy winds, must be accounted of much less value to the vegetation than the former. There is a continuous and fairly heavy rain forest on Mount Peel, from which the southern-beech, except for certain isolated patches at higher altitudes, is absent, and also the flats and the sides of the near hills at Waimate were covered originally by the same type of rain forest; but the lower slopes of Mount Torlesse, Mount Oxford, and the lesser outliers still farther north are clothed with a typical southern-beech (*N. Solanderi*) forest intermixed with scattered taxads.

Table C gives a general idea as to the greater amount of precipitation that takes place on these outliers and on Banks Peninsula than at Lincoln on the plains. It must be noted that at Oxford, Peel Forest, and more especially at Waimate, the meteorological observers are located at distances varying from two to five miles east of the mountain-base, and at Akaroa the data refer to sea-level. Undoubtedly, therefore, in each case the figures will show a lower rainfall than what is actually experienced on the mountain-slopes. This conclusion is well attested by data kindly supplied me by Mr. F. Akhurst, giving the rainfall for the period 1911–20 at three different stations in the Waimate district—viz., "Greylands," Waimate, and "Hiwiroa"—of which the first named lies three miles farther east than Waimate, and the last two miles west of Waimate in the direction of the hills. These data show that there is a very consistent increase in the precipitation as one passes westwards from "Greylands" towards the hills, the mean annual totals at the three stations for the period 1911–20—viz., "Greylands," 22·91 in.; Waimate, 26·02 in.; and "Hiwiroa," 29·74 in.—indicating very fairly what this increase usually amounts to.

TABLE C.

Years 1911–20.

—	Oxford (750 ft.)	Peel Forest (900 ft.)	Waimate (180 ft.)	Akaroa (Sea-level).	Lincoln (42 ft.).
Mean annual rainfall ..	33·91	43·53	26·02	39·86	25·19
Mean number of rainy days	113·40	118·80	129·70	93·00*	124·40

* For 1917–20 only (one month omitted from 1919 and 1920)

Whereas in Westland and on the eastern flanks of the dividing range the forest is still practically virgin, on the outlying Canterbury mountains it has been largely cut out, or even, as on Banks Peninsula, almost wholly altered or destroyed. However, the fact that there are extensive and practically untouched scenic or water-supply reserve blocks at Mount Oxford, Mount Peel, and Mount Studholme makes it possible to gain a reliable idea as to the original distribution of the Hymenophyllaceae in these localities.

(*a*.) At Mount Oxford the reserve forest covers the area included in the Cooper's Creek watershed as it now exists, stretching in altitude from about 1,000 ft. to 2,500 ft. As usual in southern-beech forest, the undergrowth is composed mainly of the beech seedlings and saplings though a few shrubs, such as small-growing *Griselinia littoralis* and small-leaved coprosmas, are scantily present. In the narrow lateral gullies these shrubs are rather more abundant, and include the large-leafed araliads *Nothopanax arboreum* and *Schefflera digitata*, and occasionally also the small-growing tree-fern *Alsophila Colensoi* and the larger *Cyathea dealbata*. For the most part the forest-floor is open and dry, there are no epiphytes, and the ferns are confined to the smaller gullies and to the steep sides of the main stream-bed.

Apparently only four species of *Hymenophyllum* are present. Of these *H. villosum* and *H. multifidum* are abundant in close colonies on the rocky walls of the main gully and on the mossy forested sides of all the gullies generally. Both are to be found also, though less frequently, on the mossy floor of the terrace-forest, where the only other ferns present are the hardier species of *Blechnum*. *H. sanguinolentum* is the only lowland

species present, and this is restricted to one or two especially damp localities in the lower part of the main gully. *H. peltatum* is not uncommon at rather higher altitudes in close mats on boulders and on the rocky sides, more especially in secluded gullies. Such ferns as were found to occur commonly in the southern-beech forests on the eastern flanks of the dividing range are present here on the main gully-walls, and in addition abundant *Polypodium grammitidis.* Intersecting the terrace in the main valley are several narrow and damp gullies in which such hygrophilous and shade-loving ferns as *Blechnum Patersoni, Dryopteris pennigera,* and *Leptopteris hymenophylloides* are commonly present. A few days previous to my visit there had been an unusually violent dry north-west gale, and even in these secluded gullies its effect had been felt, for the edges of the fronds of the *Leptopteris* were shrivelled. In the more open main gully and on the forest-floor generally, where the drying effect of the wind must have been severe, neither *H. villosum* nor *H. multifidum* showed signs of shrivelling, thus bearing witness to their hardy nature.

From a locality, now denuded of forest, at a somewhat lower altitude Mr. G. Anderson, of West Oxford, has kindly sent me specimens of both *H. minimum* and also stunted *H. Tunbridgense* which were growing scantily on a rock-face in a creek-bed. As shown in my previous paper, the former species has a fairly wide range in Westland, but the latter is a lowland plant. The presence of these two additional species suggests that in the original Oxford forest at any rate, at its lower levels still other species, as, for example, *H. sanguinolentum,* may have been present on damp rock-walls in the watercourses, but in the existing forest the distribution is practically restricted to the three species which throughout the Canterbury forests are the most widely occurring of all.

(*b.*) With respect to Peel Forest my own observations are supplemented by those of Dr. H. H. Allan, who has made a special study of the plant ecology of this area. The higher humidity of Peel Forest as compared with that of Mount Oxford is clearly shown in the fact that the ferns which in the Oxford forest gullies are altogether rupestral are here abundantly present as epiphytes in thick moss on the shrubby trees in the Kowhai Creek bed at corresponding altitudes, and the more hygrophilous species are luxuriant on the mossy creek-sides. The three filmies, *H. villosum, H. multifidum,* and *H. peltatum,* which are all widely distributed throughout the Eastern Botanical District, are here abundantly present both as epiphytes, and also, in the case of the two latter, in sheets on the gully-walls. *H. villosum* adopts altogether the epiphytic station, climbing the shrubby trees in the creek-beds to a height of 15 ft., and always overtopping the other two species. *H. demissum* is also present in frequent terrestrial colonies, and *H. sanguinolentum* is occasionally to be found as a low epiphyte. The outstanding feature in the Hymenophyllaceae of Peel Forest, however, is the presence of *H. pulcherrimum* on the walls of the Kowhai Creek Gully throughout its entire length, and of *H. scabrum* in large sheets on the gully-sides in one or two especially secluded places. The former of these two species, as has already been stated, keeps almost entirely to mountain ravines, but yet is not an extreme hygrophyte. However, its marked abundance and luxuriance in the Peel Forest gullies is a significant feature. *H. scabrum* is undoubtedly a more hygrophilous plant, and its presence is an even clearer indication of the constantly high humidity of these gullies. On the forest-reserve slopes *H. flabellatum* occurs scantily on the bases of the stems of the tree-fern *Hemitelia Smithii,* but *H. multifidum* is the only species which is at

all abundant outside the actual gullies, spreading in sheets on the damp forest-floor. Above the forest-line, according to Dr. Allan's observations, this latter species, with *H. villosum*, occurs on damp rock-surfaces up to an altitude of about 4,500 ft. Compared, then, with the forest of Mount Oxford, that of Mount Peel shows itself in its Hymenophyllaceae to be quite of the rain-forest type, this being apparent both in the number of species and of individuals, and also in the station adopted by many of them. Compared, on the other hand, with their occurrence in the Westland forests, the species here are seen to be by no means the most hygrophilous of the family, and are also almost altogether those which have in Westland a wide altitudinal range or are purely upland plants. Moreover, they do not extend outside the narrow gully-beds to any marked extent, and their vertical range is restricted.

(*c.*) The largest extent of forest now existing in the Waimate neighbourhood is that in the water-supply area of Kelsey's Valley. This valley extends eastwards for a length of about two miles from the foot of Mount Studholme (3,650 ft.), in the Hunters Hills. At its lower end, distant four miles from Waimate, it lies at an altitude of 550 ft., and at the foot of Mount Studholme at about 1,400 ft. This forest, therefore, differs from that of Mount Peel and Mount Oxford in belonging almost wholly to lowland altitudes. As indicated above, its rainfall will be considerably greater than that recorded for Waimate itself.

From the lower end of the valley upwards there is the same general epiphytic fern flora on the shrubby trees in the stream-bed as at Peel Forest, although the stems of the tree-ferns are for the most part bare. The presence in the lower third of the valley of the three species *Hymenophyllum sanguinolentum*, *H. australe*, and *H. Tunbridgense*, the first named as an abundant low epiphyte, and the two others more scantily on the gully-walls, marks this locality as belonging to the lowlands. Farther up the valley, where also the shrubbery becomes more closed in, and the humidity, as evidenced by the wealth of mosses and liverworts, is higher, the upland species *H. villosum* and *H. peltatum* are predominant, the former being both low epiphytic and terrestrial, and the latter restricted entirely to the walls of the gully. *H. bivalve* and *H. multifidum* are also here present in thick moss on the creek-sides, and *H. demissum*, though somewhat less commonly. Although the characteristically lowland and upland members of this list are, as already indicated, predominant in the lower and in the higher reaches respectively of the main ravine, *H. sanguinolentum* is scantily present in one or two places as a low epiphyte up to 1,200 ft., and *H. peltatum* extends, but also scantily, well down into the lower reaches. The humidity, then, of the actual ravines of Kelsey's Valley will be, on the whole, somewhat lower or perhaps more variable than that of the Kowhai Creek at Mount Peel, this being clearly seen from a comparison of the list of species of Hymenophyllaceae present in each locality and in the degree of epiphytism shown by them. Moreover, the general facies of these two lists corresponds with the altitudes of the two localities as given above, using the facts concerning the behaviour of the species in Westland as a standard for comparison. As in Mount Peel, the Hymenophyllaceae in Kelsey's Valley are restricted to the deeper ravines, this being probably the case also in the original state of this forest.

(*d.*) The forests of Banks Peninsula have now nearly all been destroyed, so that it is not possible to describe with certainty the distribution of its filmy-fern flora. Laing (25) has carefully studied this area in its present

state, and has brought together what can be known from both present and past researches of the primitive state of its plant-associations. Martin (26) has still further studied the Pteridophytes of the Peninsula, and has succeeded in adding to the information contained in Laing's paper. J. B. Armstrong (5), in a general account of the flora of the Canterbury Province, published in 1879, when the forests were still largely untouched, gave special attention to the fern flora of Banks Peninsula. The following summary is based upon these three papers:—

The ridges, slopes, and valleys of the greater part of the Peninsula were originally covered with a continuous sheet of rain forest up to about 2,500 ft., the summits of a few of the highest peaks (*e.g.*, Mount Herbert, 3,014 ft.) alone rising above it. Up to 2,000 ft. the composition of this forest was very much that of the lower slopes of Mount Peel, except that the rimu also was scantly present, as well as certain characteristic northern trees and other plants. The lower stories were more closed in than in the case of any of the other forests of the Eastern Botanical District, there being a greater variety and abundance of shrubby trees and tree-ferns. Lianes and epiphytes were abundant, more especially in the gullies, and the tree-fern stems were commonly clothed with species of Hymenophyllaceae. The forests of this area certainly provided a more favourable home for the Hymenophyllaceae than those of the Eastern Botanical District already considered. This fact accords well with the geographical position of Banks Peninsula (see maps 2 and 3, on pages 73 and 76), and also with the general rainfall data recorded at Akaroa at sea-level (see Table C, on page 77).

Moreover, the strong, dry, north-west winds are less frequent and less severe on the Peninsula than on the plains, and in the gullies would have comparatively little effect. Thus its climate approaches nearer to that of Westland than that of any other part of the Eastern Botanical District. However, as Laing has pointed out (25, p. 364), the absence from the Peninsula of such common Westland trees as the southern rata (*Metrosideros lucida*), the kamahi (*Weinmannia racemosa*), and *Phyllocladus alpinus*, all of which are abundant also in the damp forests of Southland, is a sign of its drier climate. There is no doubt also that its filmy ferns were more restricted to the gullies, and were less epiphytic in habit, than in Westland.

In his list (5, p. 346) of the Hymenophyllaceae of the Peninsula, Armstrong enumerates, among others, all those species which have been described above as occurring elsewhere in Canterbury, with the exception of *H. villosum*, which species, however, Laing has found to occur on one of the peaks. In addition Armstrong mentions the following: *H. rarum*, *H. dilatatum*, *H. ferrugineum*, *H. Malingii*, and five species of *Trichomanes* -viz., *T. Lyallii*, *T. humile*, *T. venosum*, *T. elongatum*, and *T. Colensoi*. Of the species thus enumerated a considerable number have been reported also by Laing and Martin. It would seem, as Laing sets forth in detail (25, p. 372), that certain of Armstrong's identifications, more especially with regard to the flowering-plants, are to be doubted. So far as the Hymenophyllaceae are concerned I see no reason for doubting any of the members of the list, although Laing queries three species of *Hymenophyllum* and four of *Trichomanes*. Of these *T. humile* and *T. elongatum*, as has been mentioned earlier, are typically northern species. They are absent from Westland, but Cheeseman (10) records them from various localities in the Nelson and Marlborough Provinces. Seeing that there is a strong northern element in the Peninsula flora, it is not unlikely that these two species originally occurred there. Martin records the fact that a collector other

than Armstrong has reported the occurrence of *T. humile*, and he has very kindly forwarded me specimens of this species from this collection. *T. Colensoi* also is mentioned by Martin as having been reported by the same collector, and of this species also he has kindly forwarded me specimens said to have been gathered on the Peninsula. If the hygrophilous *T. Colensoi* was present there would seem to be no climatic reason why *T. Lyallii* also should not have been there. On the other hand, the apparent absence of *T. reniforme* is rather remarkable. As has been shown in my previous paper, this species is less hygrophilous than the other two members of its group—viz., *H. dilatatum* and *H. scabrum*—and, moreover, Armstrong has recorded it (5, p. 346) from elsewhere in the Canterbury Province. The presence on the Peninsula of *T. venosum* on tree-fern trunks has been corroborated by Laing. Of the three species of *Hymenophyllum* in Armstrong's list queried by Laing—namely, *H. scabrum*, *H. pulcherrimum*, and *H. ferrugineum*—the two former still exist in Peel Forest, and the latter would find a very suitable home along with *T. venosum* on the abundant tree-fern stems in the temperate humid gullies of the Peninsula.

I have to thank Professor A. Wall, of Canterbury College, for drawing my attention to the fact that *H. rarum*, *H. sanguinolentum*, and *H. Tunbridgense* all occur on the damp, shaded southerly faces of the Mount Pleasant lava-rocks overlooking Lyttelton, at an altitude of about 1,500 ft. The two former I found to adopt there the same stunted mat form in which they are found in Westland as high epiphytes, and *H. Tunbridgense* also was in very close mats on the vertical rock-faces.

It seems clear that originally the forests of Banks Peninsula possessed a filmy-fern flora which was very rich in species, but which was probably largely confined to the gullies. Compared with the other Eastern Botanical District forests, the outstanding feature was the presence of the greater number of the species of *Trichomanes*, and, generally speaking, of those members of the family, both lowland and upland, which are especially hygophilous.

D. *Comparison with Westland.*

In the wet forests of Westland the Hymenophyllaceae as a whole are epiphytic rather than terrestrial. East of the dividing range, on the other hand, though probably originally to a less extent on Banks Peninsula than elsewhere, the terrestrial station is that characteristically adopted by them.

At subalpine altitudes in Westland it was found that *H. villosum* alone tends to preserve the epiphytic habit, and this is to be seen also in the eastern subalpine rain forest. The difference in humidity between the southern-beech forest of Mount Oxford and the rain forests of Mount Peel and Waimate is brought out in the fact that in the former *H. villosum* is invariably restricted to the ground, together with the other few species present, whereas in the latter not only this species but also *H. multifidum*, *H. peltatum*, and *H. sanguinolentum* are able to adopt a low epiphytic station in deep shaded gullies. The species which in the Mount Peel and Waimate rain forests are able to adopt the low epiphytic station belong to that group which in the lowlands of Westland ascend to the tops of the highest trees, with the addition of *H. peltatum*, which in the ravines of the western flanks of the dividing range occurs as a low epiphyte in company with *H. villosum* and *H. multifidum*. No doubt in the humid gullies of Banks Peninsula, on account of the more equable climate, the Hymenophyllaceae were epiphytic to an even greater extent than at Peel Forest or Waimate.

To pass from the vertical to the regional distribution of the species east of the dividing range: Practically the only early source of information dealing with the forests in their less altered state is Armstrong's paper quoted above. In it he gives a list of Hymenophyllaceae which were to be found in the Canterbury Province, and he particularizes in a tabular form where each species occurred– whether on Banks Peninsula, or in the "Middle District," or in subalpine localities—and also whether they were rare, local, or abundant. It is evident from this list and from my own observations detailed above that, speaking generally, the species of *Trichomanes*, and also the specially hygrophilous species of *Hymenophyllum*, both lowland and upland, are either absent or are very locally distributed. *H. villosum* and *H. multifidum*, which in Westland have the widest altitudinal range, are, together with *H. peltatum*, the most abundantly distributed species east of the dividing range.

There are now no forests on the Canterbury Plains which can be described as altogether lowland and properly to be compared with the lowland forests of Westland. Owing to its dry southern-beech type, as well as to its altitude, the Mount Oxford forest now apparently contains only two lowland species, of which *H. sanguinolentum* is in every sense extremely restricted and *H. Tunbridgense* almost extinct. These two species are found here only at the lowest altitude. The rain forests of Mount Peel, Waimate, and Banks Peninsula, whose lowest altitudes are 1,000 ft., 550 ft., and sea-level respectively, show a corresponding increase in the number and comparative abundance of lowland species.

H. villosum does not in Westland descend to sea-level, and it preserves in Canterbury this character in its distribution. Judging from his list, Armstrong recognized *H. villosum* only in its more stunted subalpine form. In his original paper describing this species T. Kirk (22, p. 395) notes that collectors had commonly mistaken it for *H. ciliatum*, a species which has never been found in New Zealand since it was first reported from a single locality in the Nelson district some years before Armstrong wrote his paper. It is to be noticed that the latter includes *H. ciliatum* in his list, stating that it occurs in Canterbury at middle altitudes. I feel satisfied that he also must have mistaken, in some localities at least, *H. villosum* for the closely related *H. sanguinolentum*, and that he accordingly concluded that this latter species was widely distributed from the lowlands to subalpine altitudes. Again, he ascribes the same wide distribution to *H. Tunbridgense*, and I suggest that he has confused this species with *H. peltatum*. I have found the former to be a lowland and quite a local plant in Canterbury.

With regard to other usually widely-ranging species, it is noteworthy that *H. demissum*, which in Westland is abundant from sea-level to high up into the mountain forest, is very much less frequent in Canterbury. *H. bivalve* also, which occurs with *H. demissum* on the mountain-flanks of north Westland, and especially, as will be seen later, in the southern-beech forests around Nelson, is in Canterbury an infrequent species. Other widely-ranging species in Westland are the diminutive *H. Armstrongii* and also *H. rarum* and *H. flabellatum*. The former has been found in Canterbury only on wet mossy rocks and boulders in subalpine localities on the dividing range, as mentioned above. In the Westland lowlands it is extremely abundant in short moss on smooth sapling-like stems, but in the Canterbury forests such a station is not consistently damp enough. *H. rarum* and *H. flabellatum* are thoroughgoing epiphytes which can only

grow in a pendulous position. In Canterbury they have just as wide a range as in Westland, but are very local. *H. Malingii* occurs in Westland from sea-level to the subalpine forests wherever the kawaka is present. In Canterbury it seems originally to have had the same range, being reported from Banks Peninsula by Potts (30, p. 359) as occurring on the decayed trunks of both the kawaka and the mountain-totara, and from the valley of the Wilberforce River on the eastern flanks of the main ranges by F. N. Adams (see reference in Cockayne and Laing, 16, p. 343), in which locality the kawaka is the dominant tree.

The southern-beech type of forest is less favourable for the Hymenophyllaceae than is the mixed rain forest; but the comparison of the different forest types in the Eastern Botanical District with respect to their filmy-fern content is not quite so simple in the Eastern Botanical District as it will be seen to be in certain parts of the North-western District, for in the former the effect of forest type on the distribution of the Hymenophyllaceae cannot be studied apart from the effect of both altitude and general climate.

II. THE GENERAL DISTRIBUTION OF THE SPECIES IN OTHER PARTS OF THE NEW ZEALAND BIOLOGICAL REGION.

Having given a detailed account of the Hymenophyllaceae as they occur in Canterbury under different conditions of climate, altitude, and forest covering, and compared these facts with their occurrence in Westland, it becomes less necessary to describe in so detailed a way their occurrence in other parts of the New Zealand Biological Region. The following summarized facts will serve to check or amplify the conclusions which have thus far been reached in this and in my previous paper with regard to the behaviour of the species.

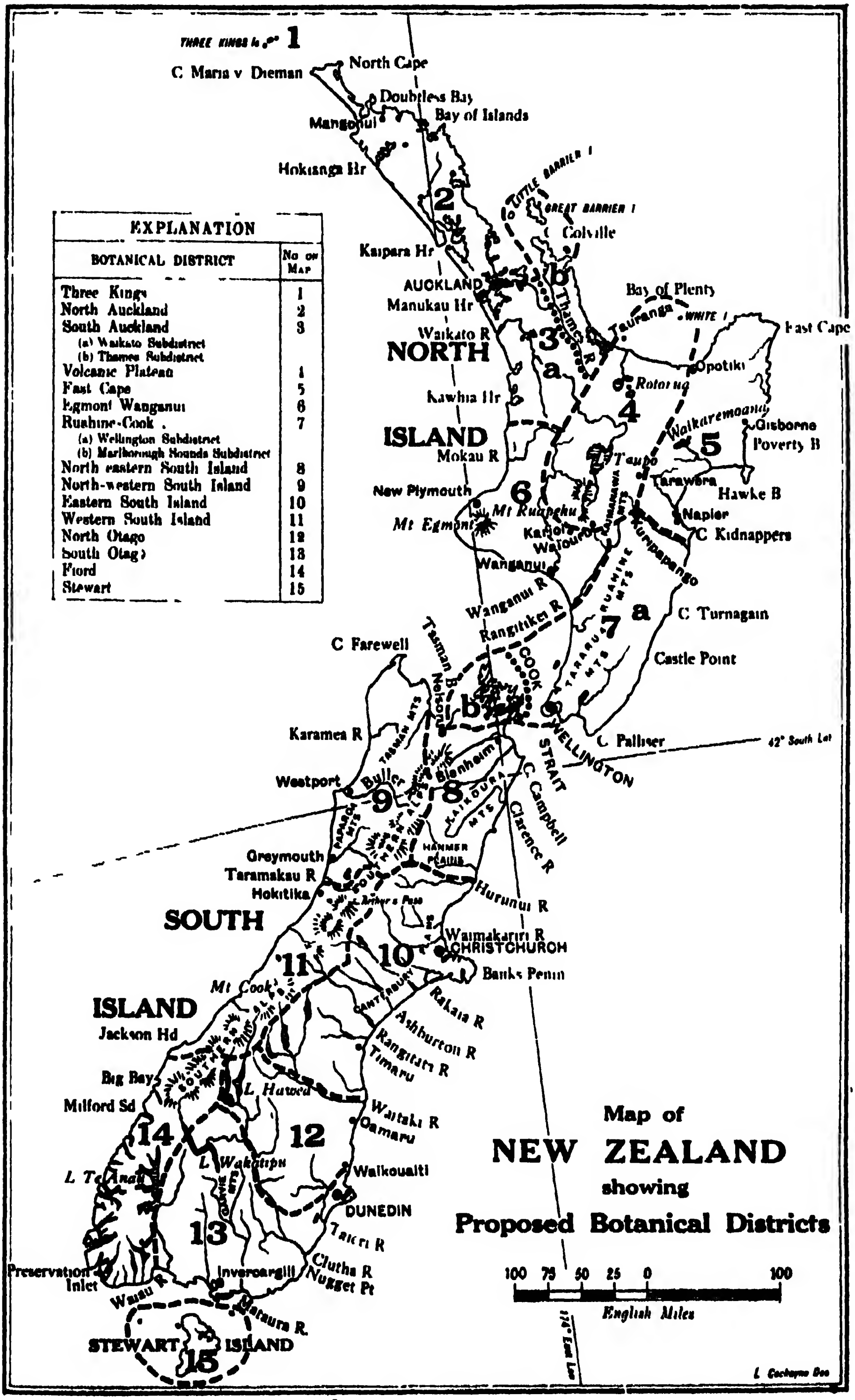
A. *South Island.*

In the neighbourhood of Dunedin, where the humidity conditions are similar to those prevailing on Banks Peninsula, and there is a comparative absence of the dry north-west wind, the taxad rain forest was originally widespread. For the period 1911–20 the average annual rainfall at Dunedin was 39·98 in., and the number of rainy days 155. From my own observations, and from the List of Species of this neighbourhood published by the Dunedin Field Club (17), it is apparent that the Hymenophyllaceae are here more abundant and also show a greater tendency to the epiphytic habit than in any of the existing Canterbury forests. Moreover, in the heavily forested gullies a few of the species range somewhat outside the actual creek-beds, and various species occur more luxuriantly still in the forests of the upper slopes of certain of the higher coastal hills where at altitudes of 1,000–1,500 ft. drifting mists are a well-marked feature. However, the extent to which they become epiphytic must be accounted quite restricted compared with their behaviour in the Westland forests. On the whole, the upland species are very poorly represented, and the same may be said of the especially hygrophilous section of the family. Thus the Dunedin forests may be classed on their Hymenophyllaceae as belonging to the lowlands, and their humidity may be reckoned to fall considerably short of the consistently high humidities of the forests of Westland.

T. Kirk (23) has published a list of Hymenophyllaceae occurring on Stewart Island, with short notes as to their relative abundance and their distribution. The rainfall at Half-moon Bay settlement, on the east coast, averaged for the period 1918 to 1920 60·85 in. per annum, and the number of rainy days 240·6. From the excessive number of rainy days it will readily be seen that the atmospheric humidity is for the most part high, a fact which Kirk points out is evident in the rapid change of vegetation into peat. The more elevated parts of the island, reaching an altitude of 3,200 ft., adjoin the west coast, and here the rainfall will be heavier. The forest-covering generally is heavy mixed-taxad rain forest, and is somewhat similar to that of Westland. *Nothofagus* is altogether absent. Kirk records the presence of twenty species of Hymenophyllaceae on Stewart Island, and notes that, whereas in New Zealand generally this family constitutes one-fifth of the entire fern flora, the proportion rises to one-third in Stewart Island. Thus Stewart Island may be more nearly compared with Westland as regards the filmy-fern flora than the forests of Banks Peninsula or of Dunedin. However, of the more hygrophilous species *T. Colensoi* and *H. scabrum* are apparently absent; *T. strictum*, *T. reniforme*, and *H. australe* are rare and local; and *H. dilatatum*, though fairly abundant, occurs on fallen logs rather than as an epiphyte. *Leptopteris hymenophylloides* and *L. superba* attain a luxuriant growth in secluded situations, but are much less widely distributed than in Westland. It is evident, therefore, that, although the climate of Stewart Island is humid, the humidity is not so favourable to the filmy ferns as in the forests of Westland, a fact which may very possibly be due to the greater prevalence of winds in Stewart Island.

The South Island North-western Botanical District presents favourable opportunities for a comparison of the distribution of the Hymenophyllaceae in heavy taxad and in pure southern-beech forests respectively under similar climatic conditions.

In the heavy taxad forests at Greymouth there is a distribution of the Hymenophyllaceae similar to that in the lowland forests of north Westland. A mile or so up the Grey Valley, immediately behind Greymouth, there is an extensive stretch of more or less flat pure *Nothofagus* forest in which there is a fairly abundant though noticeably restricted distribution of the Hymenophyllaceae. The rainfall here will be very little different from that at Greymouth, and the constantly high humidity near the ground in this southern-beech forest is attested by the fact that at low stations on the trees and on fallen logs I found an abundance of prothalli and sporeling plants of most of the species that were present. These are mainly the species which in the lowland Westland forest are mid and high epiphytes. *H. multifidum*, *H. sanguinolentum*, and *H. Armstrongii* clothe the main trunks of the trees up to a height of 20 ft. *H. dilatatum*, *H. scabrum*, and *T. reniforme* are all commonly present, as are *H. flabellatum*, *H. rarum*, and *H. Tunbridgense*, but all these are restricted to fallen logs or tree-bases up to 6 ft. above the ground. *H. demissum* is present upon the floor. The frequent presence of the upland *H. pulcherrimum* and *T. Lyallii* in a low epiphytic station is also an indication of the relatively high atmospheric humidity near the ground, but the specially hygrophilous *H. australe*, *H. ferrugineum*, and *T. strictum* are apparently absent. There are no mid-epiphytic ferns or other epiphytes other than the three species of *Hymenophyllum* first mentioned above. Pure southern-beech forest contains a very small admixture of large-leaved shrubs or shrubby trees, and



MAP 4.—Map of New Zealand, showing Cockayne's proposed botanical districts

tree-ferns are scanty. The leaves of all the *Nothofagus* species are small, and the canopy and lower story are more open than are those of the heavier mixed-taxad forest. Thus under similar climatic conditions it would appear that whereas the atmospheric humidity of the interior of the heavy mixed-taxad forest is more or less consistently high up to the mid-epiphytic station on the trees, the same high humidity is maintained only up to the low epiphytic station in pure southern-beech forest.

This comparison may be even more strikingly made with regard to the southern-beech forests of the larger lowland valleys in the close vicinity of Reefton, which lie at an altitude of from 600 ft. to 700 ft. Here the mean annual rainfall for the period 1911–20 was 75·18 in., and the number of rainy days 174·7, so that the climate may fairly be considered a wet one. There is also an absence of drying winds. In these broad valley forests only six species of Hymenophyllaceae were found, of which *H. villosum* is the most abundant, occurring both as a low and a mid epiphyte, and occasionally also on the floor. In the narrower gullies *H. multifidum* also ascends to the mid-epiphytic station, and *H. rarum* is in occasional colonies on the underside of large overhanging trees. *H. demissum* and *H. Tunbridgense* are present on the floor. *H. ferrugineum* is also to be found very scantily on the damp rocky walls of the narrowest gullies. Tree-ferns, except for the low-growing *Alsophila Colensoi*, are noticeably absent. The forest-floor is very open, and, except for occasional *Asplenium flaccidum* and *Polypodium Billardieri*, epiphytic ferns are wanting. In the more secluded and damp gullies, however, *Leptopteris superba* and *L. hymenophylloides* are frequent, and I have here seen abundant colonies of the prothalli and sporeling plants of the former species. The hygrophilous *Blechnum nigrum* and *B. Patersoni* also occur frequently in these gullies. The scanty representation of Hymenophyllaceae in this southern-beech forest is in striking contrast to their more abundant occurrence in the heavy mixed-taxad and southern-beech forest on the adjacent hillsides at altitudes of 1,200 ft. to 1,500 ft. Here there is a close undergrowth of shrubs and tree-ferns. In addition to the six species mentioned above, the lowland *T. venosum* and *H. scabrum* and the upland *H. rufescens* and *T. Colensoi* are to be found commonly in gullies in their usual stations, and *H. ferrugineum* is abundant on the dripping gully-walls, while *H. flabellatum* and *H. bivalve* occur everywhere on banks and bases of old trees. Although a forested mountain-side at these altitudes is usually wetter than the forests of the lowlands, on account of the prevalence of the mountain mists, yet at Reefton this difference in the humidity will be largely compensated for by the fact that fogs in the lowland valleys are a frequent and persistent climatic feature. The very scanty distribution of the Hymenophyllaceae in the southern-beech forests must be attributed mainly, if not altogether, to the more open character of this type of forest as compared with that of the mixed and of the pure taxad forests.

Townson (31) has published a list of plants found by him in the Westport district, including fourteen species of *Hymenophyllum* and all of those of *Trichomanes*. It is to be noted that this list includes the two typically northern species *T. elongatum* and *T. humile*, both of which seem to be absent from Westland. From Townson's brief notes on some of the species it is evident that here the lowland species reach a higher altitude than in Westland, *T. reniforme* being said to occur up to 3,000 ft., and *H. ferrugineum* and *H. Tunbridgense* up to 2,000 ft. As will be seen below, in the neighbourhood of Nelson, and to a still greater

degree in the North Island, the lowland species generally have a much wider altitudinal range than in Westland, while, on the other hand, *H. villosum* becomes more restricted to the higher altitudes.

The position of Mount Hope at the junction of the wet North-western and dry North-eastern Botanical Districts is indicated by the fact that, while such species as *H. rufescens* and *T. Colensoi* and also certain wet-loving taxads are present, the Hymenophyllaceae are much restricted in their distribution, for the most part occurring either in the beds of gullies or on the overhung sides of the large granite blocks which are scattered over the forested slopes. As noted in my earlier paper, *H. Malingii* also occurs on these granite boulders at the upper altitudes, and especially on the ground in thick moss sheltered by them, in luxuriant and dense mats, a most unusual station for this species.

The ranges which lie immediately to the eastward of the Town of Nelson come well within the North-eastern Botanical District. At Nelson itself the average annual rainfall for the period 1911 20 was 36·37 in., and the number of rainy days only 116·5, the rain coming mainly from the northward. The dry south-west wind is a characteristic feature of the climate, being, on the whole, the most frequently occurring wind throughout the year. On the east of Nelson the ranges are from 2,000 ft. to 4,000 ft. in height, and are clothed to the summits with southern-beech forest. The Hymenophyllaceae occur mainly in the gullies and on the shady south-facing slopes. Here the lowland species ascend far higher than in Westland, *H. dilatatum*, *H. scabrum*, *T. reniforme*, *H. sanguinolentum*, and *H. Tunbridgense* attaining on rock-faces on the shady flanks, both in more open situations as well as in the gullies, an altitude of at least 3,000 ft. The comparatively humid character of these shady upland forests is shown also by the abundance, though always in a terrestrial or tree-base station, of the more widely ranging species *H. rarum*, *H. flabellatum*, *H. multifidum*, *H. villosum*, *H. demissum*, and *H. bivalve*. The two latter species occur exceedingly frequently, covering the floor of the forest everywhere in extensive sheets, *H. bivalve* showing a slight tendency, as usual, to climb tree-bases and fallen logs. On the highest ridges and peaks only *H. villosum* and *H. multifidum* are present. In the Nelson forests generally the more hygrophilous lowland species *H. australe* and *H. ferrugineum* are very locally distributed, while *T. strictum*, *T. Colensoi*, *T. Lyallii*, *H. rufescens*, *H. pulcherrimum*, and *H. Armstrongii*, all of which are abundant in the wet Western Botanical Districts, are apparently absent. *H. villosum* does not descend to so low an altitude as in Westland or Canterbury.

On account of the higher altitude attained by the lowland species in the Nelson forests than in those of Westland, there is not here, generally speaking, so well-marked a differentiation in the regional distribution of the family. However, this can still be seen quite clearly in certain of the large forested gullies which lie on the unshaded north-facing hill-flanks, where the lowland species are altogether confined to the lower more sheltered reaches, even there being found on rock-faces rather than as epiphytes, while, on the other hand, the wider-ranging species mentioned above are abundant on the floor in the upper parts of the gullies, where these open out at an altitude of 1,500 ft. and upwards under the ridges and hill-shoulders. The dampness of the forest-floor at the higher altitudes in such valleys will be due to the sea-mists which frequently gather against the hillsides in the vicinity of Nelson, and this effect will be still more marked on the shaded mountain-sides on to which, as has been described above, the lowland species are able to ascend.

B. *North Island.*

With regard to the distribution of the Hymenophyllaceae in the North Island, the most outstanding feature to be mentioned is the high altitude attained by the lowland species generally. In the northern part of this Island, where there are only one or two mountains of as great an altitude as 3,000 ft., there is practically no distinction to be traced between lowland and upland species. In a description of the plant-covering of Te Aroha Mountain (3,176 ft.), at the southern extremity of the South Auckland Botanical District, J. Adams (1) remarks that the humidity of the top of the mountain makes it one of the most favourable localities for ferns, and he shows that the Hymenophyllaceae, including such species as *H. dilatatum*, *H. scabrum*, *T. reniforme*, and *H. australe*, are to be found for the most part at the summit. The same observer has reported *T. reniforme* and *T. venosum* from the summit of Te Moehau Mountain (2,750 ft.), on the Cape Colville Peninsula (2). For this reason the altitudinal range of many of the species as given by Cheeseman (10) will be far greater than what it is found to be in Westland or in other parts of southern New Zealand. In the more mountainous parts of the North Island, as in the South Island generally, *H. villosum* and *H. multifidum* ascend to higher altitudes and into more exposed positions than any other of the species. For example, J. Adams (3) has noted the occurrence of the former species on the open summit of Mount Hikurangi, in the East Cape District, at an altitude of 5,600 ft. In his Botanical Report on the Mount Tongariro National Park (13), which lies at an altitude of 3,000 ft. and upwards, L. Cockayne frequently refers to *H. multifidum* along with the hardy *Polystichum vestitum* and *Blechnum penna marina* as being the ferns which most affect the physiognomy of the southern-beech forest-floor, the *Hymenophyllum* being the most conspicuous of the mat-forming plants.

Several members of the family do not extend into the northern part of the North Island. According to Cheeseman (10), *H. pulcherrimum*, *H. peltatum*, *H. Malingii*, and *H. rufescens* reach their northern limit on Te Aroha Mountain, *H. villosum* on Mount Te Moehau, and *T. Colensoi* in ravines near Rotorua. All these are typical upland plants, and their absence from the north may be due simply to the fact that there are no high elevations to be found in that part of New Zealand. It is to be noted that the northern limit for *H. Malingii* is the same as that for *Libocedrus Bidwillii*, to which it is almost invariably restricted. Cheeseman does not record *H. minimum* from the North Island. This species is distributed, though somewhat discontinuously, throughout the South Island; it was said by T. Kirk (23) to be not infrequent in Stewart Island, and it is present also on Auckland Island (27). From these facts it would appear to be a southern plant. Oliver (2), however, has also reported it from Lord Howe Island, off the coast of New South Wales, so that there seems to be no reason for its apparent absence from the North Island. *T. elongatum* and *T. humile* are both abundant species in the Northern Botanical Districts of the North Island, and extend, though more sparsely, throughout its Southern Districts and even into the Northern Districts of the South Island. They both occur in the islands of the Western Pacific Ocean, and so may be regarded as belonging to the Malayan and Polynesian element in the New Zealand flora.

Various writers have commented upon the luxuriance of the shrubbery and other low-growing vegetation on the scoria-fields of the Auckland

Isthmus, and especially on the volcanic islet of Rangitoto, in the Auckland Harbour. Amongst other epiphytic ferns and typical forest-epiphytes growing upon the scoria, various species of Hymenophyllaceae attain a great luxuriance. T. Kirk (21) has noted the abundance of *H. australe* and *T. humile* amongst the shrub-covered scoria-blocks on the mainland, remarking that this provides a striking proof of the high atmospheric humidity in these localities. This fact gains added significance when it is remembered that these particular species are amongst the most hygrophilous in the family. Other writers have drawn attention to the fact that *H. sanguinolentum* and *T. reniforme* occur abundantly on the scoria-blocks on the slopes of Rangitoto Island in the full blaze of the sun. During the heat of the summer the fronds of these two species are shrivelled and are apparently dead, but with the autumn rains the plants are as green as ever. I have found here *H. multifidum* growing frequently side by side with the two other species; and in the damp gullies in the scoria slopes, shaded by the shrubbery, are *H. dilatatum*, *H. scabrum*, *H. Tunbridgense*, *H. australe*, all on the ground, *H. flabellatum* as a low epiphyte, and *Tmesipteris* on tree-fern stems. It may be added that many other forest-epiphytes are found on Rangitoto Island growing on the scoria, such as the orchids *Bulbophyllum pygmaeum*, *Earina mucronata*, and *Dendrobium Cunninghamii*, and the shrubby epiphyte *Senecio Kirkii*. *Psilotum triquetrum* is most abundant at the lowest levels. From the official data these is no doubt that Auckland possesses a very humid climate. The average annual rainfall at Auckland City for the period 1911 to 1920 was 49·32 in., and the number of rainy days 195·3. The mean humidity for the same period was 79·7 that is to say, 3·4 higher than at Hokitika, in Westland. There is no doubt also that the scoria-blocks, and the humus in their interstices, absorb and hold much dew as well as rain-water. The humidity of the climate is also seen in the fact that the tree-fern *Cyathea medullaris* is commonly grown in the open in the city private gardens. Nevertheless the exposed position on Rangitoto Island occupied by such a species as *T. reniforme* is remarkable. This species is able to hinder transpiration by the inrolling of the frond In the forests of Westland *T. reniforme* is able to endure as a middle epiphyte rather more exposed positions than the two other species usually associated with it. viz.—*H. dilatatum* and *H. scabrum;* and elsewhere in New Zealand it is sometimes to be found in sheets on the floor of southern-beech forests unaccompanied by the latter. On the other hand, in the neighbourhood of Dunedin, and also in Stewart Island, *H. dilatatum* is abundant and luxuriant while the other two species are scanty or absent.

I have been able to examine the forests on the eastern side of the North Auckland Peninsula at various places, and have observed that, generally speaking, the Hymenophyllaceae are more restricted to low epiphytic stations or to the floor than they are in the Westland lowland forests, or than they are, as Mr. Cheeseman informs me, in the gullies on the low western ranges of Auckland. This will probably be due to the lighter character of these eastern forests in North Auckland. As described in my previous paper, *T. elongatum* and *T. humile* form a very characteristic association on the creek-bed walls of these forests.

C. *The Outlying Islands.* (See map 1, on page 68.)

The Kermadec Islands, which lie to the north-east of New Zealand, are a widely-separated group, of which the largest island, Raoul or Sunday

Island, is distant about six hundred miles from New Zealand. Sunday Island rises to a height of 1,720 ft., and is the only one of the group which is forest-covered. The plant-covering of this island has been described by two New Zealand botanists, Cheeseman (9) and Oliver (28). The last named, who spent a year on the island, describes the climate as mild and equable, with many rainy days, considerable precipitation evenly distributed over the year, much wind in the winter months, and a constantly humid atmosphere. For the nine months February to October, 1908, the total rainfall was 67·5 in., on 176 days; and the mean humidity was 91. The more elevated parts of the island are frequently enveloped in mist; and the plant-covering here is designated by Oliver "wet forest." There are, however, no permanent streams. Four species of Hymenophyllaceae occur in the wet forests, and the following description of them is taken from Oliver's paper (p. 142): *H. demissum* is abundant everywhere in wet forest, on branches of trees, tree-fern stems, and on the ground. *H. flabellatum* is found in one place only, on the highest summit, the matted roots and close fronds covering the underside of a leaning trunk of *Metrosideros villosa*. *T. humile* is extremely rare, being found only on wet banks and fallen trunks of tree-ferns in deep shady ravines. *T. venosum* is an epiphyte of the wet forest found on the underside of leaning trunks of *Cyathea kermadecensis*. The high humidity of this upper forest is shown by the luxuriant epiphytic vegetation there to be found on leaning trunks and horizontal branches and on the tree-fern stems. The Kermadec Islands as they now exist are of volcanic origin, and the consensus of opinion seems to be that they are oceanic —at any rate, in a biological sense. The flora is closely allied to that of New Zealand, but there is also a considerable number of subtropical species. The four species of Hymenophyllaceae are all abundant in the North Island of New Zealand. The scanty distribution of this family in the Kermadecs is the more remarkable when the favourable nature of the forest is considered. From a study of the flora generally, Cheeseman concludes (9, p. 163) that the islands have been stocked with their plants by chance migrations across the ocean.

The Chatham Islands lie about five hundred miles due east from New Zealand, in the latitude of Banks Peninsula. The largest of these is about thirty miles in length, its surface consisting, on the whole, of low elevations, relieved here and there by hills, of which those in the south attain a height of 600 940 ft. Forest covers a certain portion of the main island, both in the lowland and on the higher elevations, that of the latter being especially humid, with a close undergrowth of tree-ferns in many places and with an abundance of epiphytic ferns. Two papers dealing with the plant-covering have been published in the *Transactions of the New Zealand Institute*, the first by Buchanan (6), who gave merely a list of plants collected from the main island, and the second by L. Cockayne (11), who dealt with the subject from an ecological point of view. The latter gives figures showing that at the eastern coast-line the average annual rainfall is 30·4 in., but that it is distributed over 186·6 days in the year, and adds that the rainfall is certainly heavier on the higher southern portion of the island. After going into the subject of the climate in detail he concludes that it must be reckoned exceedingly mild and equable, but that the winds are very frequent. Buchanan's list of Hymenophyllaceae occurring on the main island is as follows: *H. bivalve*, *H. demissum*, *H. dilatatum*, *H. australe*, *H. flabellatum*, *T. reniforme*, and *T. venosum*; to which Cockayne

has added *H. multifidum*. In his description of the higher-altitude forest the last-mentioned writer states that here every tree-trunk, tree-fern stem, and dead tree is covered with multitudes of filmy ferns. Epiphytic on the tree-fern stems are *T. venosum*, *H. multifidum*, *H. dilatatum*, and *T. reniforme*. The filmy ferns are often so thick that they completely hide the trunk of tree or fern on which they grow. In many cases the ground also is covered with a thick carpet of them. In deep forest-clad gullies *T. reniforme* often grows with extreme luxuriance. Cockayne concludes (p. 314) that, although lacking the most characteristic forest-trees of New Zealand, the flora of the Chatham Islands must be considered a recent offset from that of New Zealand, and he notes that the geological and zoological evidence is in favour of a former land connection. In view, however, of the absence of so many characteristic New Zealand genera, he cites Cheeseman's view of the origin of the flora of the Kermadec Islands.

The remaining outlying islands to be considered are those usually designated the Subantarctic Islands of New Zealand– viz., the Auckland, Campbell, Antipodes, and Macquarie Islands– which lie easterly or southerly from the South Cape of New Zealand at distances of 190 to 570 miles (see map 1, on page 68). The plant-covering of the two first-named groups was in part described by J. D. Hooker (19), and of all except the Macquarie Islands more fully by L. Cockayne (12). In 1907 all of the groups were thoroughly investigated by the New Zealand Scientific Expedition, and a full account published (27).

The following brief account of the climate and forest-covering of Auckland Island is taken from Cockayne: There are many rainy days, almost constant cloudy skies, very frequent winds which are sometimes of great violence, and a winter climate which is extremely mild– much milder, indeed, than that of certain parts of the South Island of New Zealand at sea-level, as, *e.g.*, the Canterbury Plains. The rata-forest zone forms a belt extending round a considerable portion of the coast of the various islands in the Auckland Group, being more luxuriant, with a richer fern flora at the heads of sheltered inlets. At altitudes of about 400 ft. it gives place to formations of scrub or meadow. The floor of the forest consists of wettish peat. The mechanical effect of the constant and heavy winds has produced a semi-prostrate, stunted and gnarled forest, but owing to the moist mild climate the trees are luxuriantly branched. The canopy of the forest, rising about 15 ft. above the ground, is very dense and keeps the interior calm, and this, combined with the great amount of moisture in the atmosphere, affords very strong hygrophytic conditions in its interior. There is a luxuriant growth of mosses, liverworts, and filmy ferns both on the floor and on the trunks and branches of the trees, and amongst other ferns the strongly hygrophilous *Leptopteris superba* is to be found in favourable localities.

Ten species of *Hymenophyllum* have been recorded from the Auckland Island rata forest – viz., *H. rarum*, *H. sanguinolentum*, *H. villosum*, *H. dilatatum*, *H. demissum*, *H. flabellatum*, *H. minimum*, *H. Tunbridgense*, *H. multifidum*, and *H. bivalve*. It will be noticed both that the above list includes the six species which on the main islands of New Zealand show themselves to be the least hygrophilous and the most consistently wide-ranging in the family, and also that it contains no species of *Trichomanes*. However, the presence of such comparatively hygrophilous species as *H. dilatatum*, *H. sanguinolentum*, and *H. Tunbridgense* is a striking proof

of the consistently high humidity of the forest-interior. *H. multifidum* is by far the most abundant species, occurring in the rata forest in its ordinary mesophytic form. On Campbell Island there is no forest, its place being taken by a dense scrub-association. The only Hymenophyllaceae here occurring are *H. villosum* and the mountain form of *H. multifidum*, the latter occurring, as in the Auckland Islands, in large abundant patches both in the subalpine meadow and on subalpine rocks. On the Antipodes Island *H. multifidum* alone has been found, while on Macquarie Island, where woody plants are altogether wanting, even this species seems to be absent. Cockayne points out (12, p. 271) that these Subantarctic Islands can be arranged in a series affording an instructive example of how arborescent plant-formations, even in a rain-forest climate, are inhibited by frequent and violent winds, and their place taken by meadow growths, which, notwithstanding the winds, are so stimulated by the moisture as to be of very great luxuriance In the same way this series indicates *H. villosum* and *H. multifidum* as being the hardiest species of the Hymenophyllaceae, as also they are seen to be on the mainland of New Zealand.

III. General Conclusions.

1. The conclusions reached as to the altitudinal distribution of the Hymenophyllaceae in Westland, set forth in Part 1 of these Studies (18), are borne out by their behaviour in the drier parts of the South Island, and in other parts of the New Zealand Biological Region, except that northward the lowland species attain progressively higher altitudes.

2. The conclusions reached as to the vertical distribution of the species in the Westland forests (18) are also borne out by their behaviour in other parts of the New Zealand Biological Region, except that nowhere do they so thoroughly adopt the epiphytic habit as they do in Westland.

The comparative study of the fern floras of the forests of different localities shows that the extent to which the ferns generally and the Hymenophyllaceae in particular adopt the epiphytic habit is a reliable indication as to how far the high humidities in the forest-interior can be regarded as consistent.

3. Those species which in the comparatively dry Eastern District of the South Island have the widest altitudinal range viz., *H. villosum* and *H. multifidum* and which, along with *H. peltatum* and *H. sanguinolentum*, must be reckoned to occur there the most abundantly, are always the first to begin to adopt the epiphytic habit.

4. The comparison of the heavy mixed-taxad and the pure southern-beech types of forest in localities where, as in the vicinity of Reefton, these occur in close proximity shows that the latter, on account of its poverty in large-leaved shrubs and shrubby trees and tree-ferns, is unable to preserve in its interior, except perhaps at or near the floor, a constantly high atmospheric humidity even when the rainfall and the number of rainy days experienced is large; and also that it is unable to afford favourable epiphytic stations for the majority of the Hymenophyllaceae, on account of the absence from it of large irregularly-shaped tree-bases and low-spreading horizontal branches. It is possible that it is mainly on account of this latter reason that the eastern forests of North Auckland also do not show such an abundant filmy-fern flora as do the forests

of Westland, although the atmospheric humidity in the former remains undoubtedly high.

5. It was shown (18) that in Westland a large proportion of the species occur in groups according to their habits. These natural groups can be recognized also in other districts of New Zealand; but differences between the members of a group are shown by the manner of their response to varying climatic conditions in lighter types of forest, which differences are in some cases discernible also in their behaviour in the forests of Westland.

6. The species, both lowland and upland, including nearly all those of *Trichomanes*, which were shown (18) to be in the Westland forests the most hygrophilous of the family are either altogether absent from the drier forests of Canterbury and Nelson or are the most locally distributed.

7. The geographical distribution of the family in the New Zealand Biological Region is to be seen with respect to several of the species. *T. humile* and *T. elongatum*, both abundant in the north, become less so farther south, and in this direction do not extend beyond the northern parts of the South Island, Banks Peninsula being apparently their southern limit. These two species belong to the Malayan element in the New Zealand flora. On the other hand, the following species viz., *H. pulcherrimum*, *H. peltatum*, *H. Malingii*, *H. rufescens*, *H. villosum*, and *T. Colensoi* all of which, with the exception of *H. Malingii*, which occurs also in Tasmania, are endemic to New Zealand, find their northern limit, together with certain upland phanerogams, at or about the extreme southern end of the South Auckland Botanical District. These species are typical upland plants, and it may be that their absence from the northern part of the North Island has no phytogeographical significance, but is due to the absence from those parts of mountains of any considerable elevation. *H. minimum*, so far as the New Zealand Biological Region is concerned, seems to have its centre of distribution in the extreme south, but it has also been reported from Lord Howe Island.

8. The outlying islands of the New Zealand Biological Region do not possess any Hymenophyllaceae which are not present in New Zealand itself, and, judging from the composition of their filmy-fern flora, the occurrence in them of members of this family would seem to have resulted rather from chance dispersal from New Zealand or from elsewhere than from the effect upon a once larger number of species of a changing climate due to a shrinking and subsiding land-area. Of the endemics, *H. villosum* occurs in the Auckland and Campbell Islands, and *T. reniforme* on Chatham Island.

9. Of the nine species which are endemic to the New Zealand Biological Region, three viz., *H. villosum*, *H. rufescens*, and *H. atrovirens* can possibly be regarded as specialized forms of other species also present in New Zealand—viz., *H. sanguinolentum*, *H. flabellatum*, and *H. australe* respectively. *T. strictum* is said to be most nearly related to the widely-spread *T. rigidum*. With regard to *H. minimum*, J. D. Hooker (20. p. 104) has suggested the cosmopolitan *H. Tunbridgense*, or the Polynesian *H. multifidum*, or the Fuegian *H. caespitosum* as the species to which this plant is most closely allied. Concerning the remaining endemic species nothing can here be suggested as to their possible affinities, but it must be noted that they are all very distinct from other New Zealand species and are markedly specialized.

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Descriptions of New Native Flowering-plants.

By D. PETRIE, M.A., Ph.D., F.N.Z.Inst.

[*Read before the Auckland Institute, 14th December, 1922; received by Editor, 28th December, 1922; issued separately, 26th May, 1924.*]

1. Pittosporum Turneri sp. nov.

Species *P. patulo* Hk. f. affinis; differt ramis ramulisque gracilibus; foliis maturis brevioribus tenuibus integris cuneato-obovatis, subtus pallidis, 2·5–3·8 cm. longis, 9–13 mm. latis (apices versus); capsulis globosis multo minoribus, haud compressis, 7 mm. in diam.

A small tree 4·5–9 m. (15–30 ft.) high, up to 2·3 dcm. (9 in.) in diameter; when mature pyramidal in outline with the lower ½–⅔ bare of branches (except in juvenile state), bark brown or greyish-brown, generally smooth. Branches fastigiate, more or less whorled, rather slender, short for height of tree, branchlets numerous very slender. Mature leaves alternate, 1–1½ in. long by ⅜–½ in. broad near tips, cuneately obovate, shortly petioled, entire, glabrous (except when young), rather thin, brownish-green above, much paler below; midrib obscure above, evident below, as are also veins. Flowers in terminal umbels of 6–12 mostly on short lateral shoots, pink or purplish, pedicels short slender silky, lengthening but little in fruit. Sepals thin narrow-lanceolate acute, much shorter than strap-shaped subacute reflexed petals; stamens shorter than petals; pistil conical silky-pubescent, style rather long. Capsule globose, not compressed, 2-celled, 5–6 mm. (¼ in.) in diameter, when mature glabrous more or less muricate blackish-brown crowned by persistent style.

Juvenile plants form a little above the ground a column-like tangled mass, up to 2 ft. in diameter and several feet high, of slender divaricating and tortuous branchlets and twigs, which fall away from the adult tree. At this stage the leaves are highly variable in size but less so in shape, ranging by fine gradations from 3 mm. (⅛ in.) to upwards of 2 cm. (¾ in.) long, usually more or less cuneately obovate, entire or with a few oppositely placed indentations above the middle.

Habitat.—Waimarino Plain, at edge of forest, some two miles south of the Waimarino Railway-station: E. Phillips Turner (1909), H. B. Matthews and H. Carse (Jan., 1921)! Arnold Wall (Feb., 1922)!

Mr. Turner, to whom the species is dedicated, discovered it in the district where Matthews and Carse afterwards collected specimens. He definitely refers to it in his "Report on the Vegetation of the Higher Waimarino District" (Government Printer, 1909), but I have seen no specimen from him. Mr. Matthews has kindly supplied many of the particulars embodied in the above description. He thinks the plants may be ten to fifteen years old before they assume the adult form. They flower late November to early December. The juvenile state of *P. patulum* has not, so far, been described in detail. It would be interesting to learn if it goes through changes like those found in the present plant. It was only after prolonged search that Mr. Matthews found a single juvenile plant, which was recognized by its beginning to produce mature branches and leaves. Wall also collected the juvenile state.

2. Senecio remotifolius sp. nov.

Frutex ramosus, 12 18 dem. altus. Ramuli petioli et inflorescentia tomento subflavido v. cinereo-flavido vestiti. Folia late elliptica, ad 11 cm. longa (petiolo excluso) c. 7 cm. lata, subacuta, parum coriacea, supra tomento albido hic et illic ± aspersa, subtus tomento subflavido appresso vestita; petiolis foliis ± aequilongis, ± gracilibus, supra sulcatis. Inflorescentia axillaris elongata parce divisa; rhachis anfracto-flexuosa, infra ramos paucos alternos breves capitula pauca gerentes edens, a parte summa simplex. Capitula discoidea c. 6 mm. longa; involucri squamis c. 8 linearibus tomentosis; flosculis c. 12; corollae limbo anguste infundibuliformi subalte 5-dentato, segmentis revolutis. Achenia linearia breviter pilosa.

A sparingly-branched shrub 4–6 ft. high, rarely more. Leaves broadly elliptic, 4¼ in. long (exclusive of the petiole), 2¾ in. broad, subacute, little coriaceous, margins obscurely sinuate in upper half, midrib and veins conspicuous on both surfaces, dull green above with scattered streaks of whitish tomentum chiefly along midrib and veins, below clothed with pale-yellow or greyish-yellow appressed tomentum; petioles about as long as blades, rather slender grooved above, clothed as is also inflorescence with greyish appressed tomentum. Inflorescence axillary near ends of the branches up to 5¾ in. long; rhachis more or less zigzag, giving off below several alternate short more or less divaricating few-flowered branches subtended by small narrow foliaceous bracts becoming linear higher up, terminal part simple. Heads on short pedicels discoid, involucral scales about 8 linear tomentose; florets about 12; limb of corolla narrow funnel shaped rather deeply 5-toothed, segments revolute. Achenes linear shortly pilose.

Habitat.- North and south of Mokau River in open rocky spots toward the coast, not plentiful: W. A. Thomson! The specimens examined were grown in Mr. Thomson's garden at Half-way Bush, Dunedin, from young plants taken from the wild habitat.

3. Veronica Carsei sp. nov.

Species *V. laevi* Benth. arcte affinis; differt foliis longioribus elliptico-lanceolatis ad 3·2 cm. longis et 1 cm. latis, acutis, tenuioribus, plerumque patentibus, sessilibus, distantioribus, racemis 4 6 simplicibus, multo longioribus (ad 7·3 cm. longis), a parte inferiore nudis; corollae tubo longiore, limbi lobis ovatis subacutis; capsulis maturis adhuc ignotis.

A shrub 6·5–20 dcm. (2 6 ft.) high, usually about 1·5 m. (4½ ft.), branching virgately from base, bark dark brown; branches slender ascending glabrous, twigs leafy towards tips, lower parts ringed with scars of fallen leaves. Leaves decussate, spreading (rarely somewhat overlapping), variable in size, ¾ 1¼ in. long, ⅕ ⅜ in. broad, elliptic or elliptic-oblong, acute, entire, glabrous, little coriaceous, usually flattened, lower half narrowing gradually to rather broad sessile base, more or less polished above paler below, drying reddish-brown, midrib depressed above and forming a prominent keel below. Racemes 4–6 near ends of twigs, simple, 1½–3 in. long, naked below, many-flowered; rhachis rather slender, sparsely pubescent-pilose; bracts narrow acute, about as long as the pubescent pedicels; flowers white often tinged with pale purple, ± 8 mm. (⅓ in.) long, shortly pedicellate; calyx ⅓ as long as the corolla, 4-partite, segments broadly ovate subacute ciliate at edges; corolla-

tube twice as long as calyx or rather more, ± 15 mm. ($\frac{1}{16}$ in.) wide, lobes of limb ½ as long as tube subacute. Ripe capsules not seen.

Habitat.—Margins of forest and woods, Waimarino Plain: W. Townson! H. Carse! H. B. Matthews! Kaimamawa Range: B. C. Aston!

Named in honour of Mr. H. Carse, whose botanical investigations have been of great value. He remarks that the plant, though not uncommon on the Waimarino Plain, is rarely found in any great quantity. I understand that Mr. Cheeseman's character of *Veronica laevis* Benth., given in his *Manual of the New Zealand Flora,* includes the present species as well as the true *V. laevis,* to which the former is certainly close.

4. Euphrasia Wilsoni sp. nov.

Annua? Caules ad 4–6 cm. alti, pro plantae magnitudine crassiores, a basi ramosi, ramulis gracilibus ± elongatis cum ramis bifario pubescentibus. Folia magnitudine variabilia, paribus oppositis disposita, a parte ramulorum superiore conferta, in statu vivo succulenta, basi lato sessilia, c. 13 mm. longa et 10 mm. lata, cuneato-obovata, dentibus 3–4 subcrassis utrinque a parte superiore praedita, conspicue 3-nervata, a marginibus revoluta. Flores axillares pedunculos longiusculos pubescentes terminantes, ± 13 mm. longi; calyx corolla dimidio brevior, ad medium 4-lobatus, lobis latioribus subacutis a marginibus revolutis; corollae tubo infundibuliforme ± pubescente, labio superiore 2-lobato, inferiore alte 3-lobato, lobis omnibus integris obtusis v. subacutis. Capsulae maturae haud visae.

Annual? Stems 3·75–6·25 cm. (1½–2½ in.) long or less, often crowded, stout for size of plant, branched from base, dark brown; branchlets slender, often elongated, and, like stems and branches, bifariously pubescent. Leaves variable in size, in opposite pairs, lower rather distant, crowded towards tips of branchlets, succulent when fresh, sessile by a broad base, ± ½ in. long by ⅜ in. broad about middle, cuneately obovoid with 3–4 rather coarse teeth on either side along upper third, glabrous, obtuse or subacute, moderately thick and coriaceous, prominently 3-nerved, recurved at edges and marked with shallow depressed areoles on back behind teeth and running down irregularly from these, bracts similar to leaves but smaller. Flowers axillary on rather long usually slender pubescent naked pedicels, ± ½ in. long, (apparently) white; calyx about half as long as corolla, slightly pubsecent, 4-lobed to middle, lobes broad subacute recurved at edges; corolla-tube funnel-shaped, more or less pubescent; upper lip shortly 2-lobed, lower deeply 3-lobed, all the lobes entire obtuse or subacute. Fully formed capsules not seen.

Habitat.—Ruahine Range (western slopes), 3,500 5,500 ft.: R. A. Wilson! Arnold Wall! B. C. Aston. Collected early in January, 1922.

This very distinct species is named in honour of Major Robert A. Wilson, D.S.O., who first collected it in company with Messrs. Wall and Aston. In the specimens examined there was nothing to suggest a perennial habit of growth. The plant, Major Wilson informs me, was found growing only on patches of a *Raoulia* and a *Poa,* on the roots of which it was more or less parasitic. Where the *Raoulia* had died off the *Euphrasia* had died with it, and where the *Raoulia* was sickly and decaying the *Euphrasia* was in the same condition. The parasitic habit

would thus appear to be more pronounced than in the other native species of the genus.

5. Veronica Dartoni sp. nov.

Frutex conferte ramosus, 9–14 cm. altus; ramuli graciles glabri brunnei. Folia decussata valde approximata patentia anguste obovata, apicibus subacuminatis, in basim latum sessilem $\pm$ ciliatum angustata, vix membranacea, integra glabra, haud carinata, costa media supra infraque evidente, $1\frac{1}{4}$–2 cm. longa $\frac{3}{4}$–1 cm. supra medium lata. Racemi 2–4 in axillis foliorum superiorum dispositi, breviter pedunculati piloso-pubescentes suberecti, 4-6 cm. longi, subangusti. Flores $\pm$ 5 mm. lati approximati, pedicellis brevibus piloso-pubescentibus bracteas lanceolatas acutas ciliatas vix aequantibus; calyx 4-partitus, lobis ovatis acutis secundum margines ciliatis; corolla caesio-albida, tubo sublato sepalis subduplo longiore, lobis obtusis tubum aequantibus, staminibus corollam aequantibus, antheris purpureis, stylo exserto. Capsula $\pm$ 4 mm. longa $\pm$ $2\frac{1}{2}$ mm. lata, acuta, calycem subduplo excedens.

A compactly branched shrub 3–5 ft. high; branchlets slender, ascending, glabrous, reddish-brown, closely ringed by scars of fallen leaves; old bark dark brown. Leaves decussate, more or less spreading, very closely placed along ultimate twigs, narrow obovate, subacuminate at tips, below gradually narrowed into a rather broad sessile more or less ciliated base (the opposite pairs clasping or almost clasping the twigs), glabrous hardly membranous, entire, not keeled, midrib evident above and below with two obscure sublateral veins, $\frac{5}{8}$–$\frac{3}{4}$ in. long $\frac{3}{10}$–$\frac{3}{8}$ in. wide (just above middle). Racemes 2–4, oppositely placed in axils of uppermost leaves, shortly peduncled, rather slender, pilosely pubescent, suberect, 4–6 cm. long. Flowers about 5 mm. across, closely placed on very short pubescent pedicels that nearly equal the lanceolate acute strongly ciliate bracts. Calyx 4-partite, lobes ovate acute, strongly ciliate along edges; corolla lavender or whitish-lavender, tube rather wide, $1\frac{1}{2}$ times as long as sepals, lobes obtuse and as long as tube, stamens equalling corolla, anthers purplish, style exserted. Capsules about 4 mm. long and $2\frac{1}{2}$ mm. broad, acute, glabrous, $1\frac{1}{2}$ times length of calyx.

Habitat.—Firewood Creek, Cromwell: D. P. Roxburgh, on steep banks of Clutha River, a little below the bridge: H. L. Darton!

A very curious plant, whose position in the serial order of the species is somewhat obscure. It is named in honour of Mr. H. L. Darton, of the Lawrence High School, well known, with his colleague Mr. Hart, for enthusiasm in collecting and growing every obtainable form of *Veronica*. I collected it in 1911. Mr. Darton's specimens were found in December of the present year. I am not sure of the colour of the flowers, of which only dried specimens have been available for examination.

The Structural Features of the Margin of Australasia.

By W. N. BENSON, B.A., D.Sc., F.G.S., F.R.G.S., Professor of Geology, Otago University.

[*Read before the Otago Institute, 12th December, 1922*; received by Editor, 31st December, 1922; issued separately, 26th May, 1924.*]

IN previous papers the writer (1923, 1924) has summarized the various hypotheses concerning the growth of Australasia, the distribution and nature of the Palaeozoic and Mesozoic marine rocks, and the location and conditions accompanying the intrusion of the basic and ultrabasic plutonic rocks. These all indicate the peculiar interest attaching to the northern and eastern margins of the Australasian area. In the present paper it is proposed briefly to discuss the tectonic features and later geological history of this marginal zone, following it down from the East Indies to New Zealand, and to note whether by so doing any new light is thrown on the structure or history of New Zealand itself. Attention will be confined to the western and southern islands of the East Indies, New Guinea, and the other islands of the first Australian arc of Suess (1909), and but little discussion will be given of the area within the Fijian lobe of the Australasian margin indicated by Marshall (1911), or the more extensive regions between the first and third Australian arcs of Suess. Concerning these, however, we shall merely note Suess's comment (1909, p. 517) on the possibility that Vitu Levu may be part of an older segment between the branches of a virgation spreading northwards from New Zealand, to which the Kermadec–Tonga trench forms the foredeep. Consideration will also be omitted of the still more widespread influence of the Australasian tectonic system implied in recent papers by Andrews (1922) and Hobbs (1922) on the growing mountain-ranges on the floor of the Pacific. Such omission does not imply a denial that these areas come within the influence of the Australasian tectonic system, but only that the present writer is unable to add anything of moment to the discussion of the points raised. This discussion is to be found in the work of Woolnough (1903), the authors cited above, and others to which the reader is referred.

Commencing with an account of the Malay Archipelago: It has been shown by recent geological studies — *e.g.*, those of Molengraaff (1921), Wing Easton (1921), and Brouwer (1922)—that the line drawn by Wallace to divide the Malay Archipelago into an Asiatic and an Australian biological province has also a tectonic importance. It separates a western relatively stable region of islands rising from the shallow Sunda and South China Seas, wherein the Tertiary sediments are but slightly folded, from an eastern area of marked instability and intense Tertiary orogeny in which folding continues up to the present era. This second region, again, is bounded by a line drawn round the south-eastern margin of the Banda arc and eastwards through southern New Guinea, separating it from the stable region of the Sahul Bank, Arafura Sea, and southern New Guinea, the outlying portions of the

* Also in Wellington before the sixteenth meeting of the Australasian Association for the Advancement of Science, January, 1923.

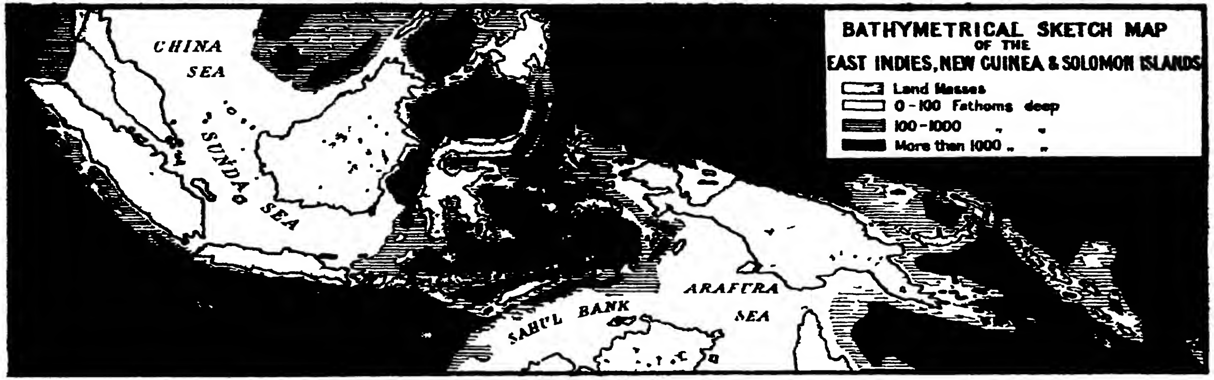

FIG. 1.—Bathymetrical map of the Malay Archipelago, &c., based on data assembled by Molengraaff and Tydeman (1921 Sieberg (1910), and Groll (1912).

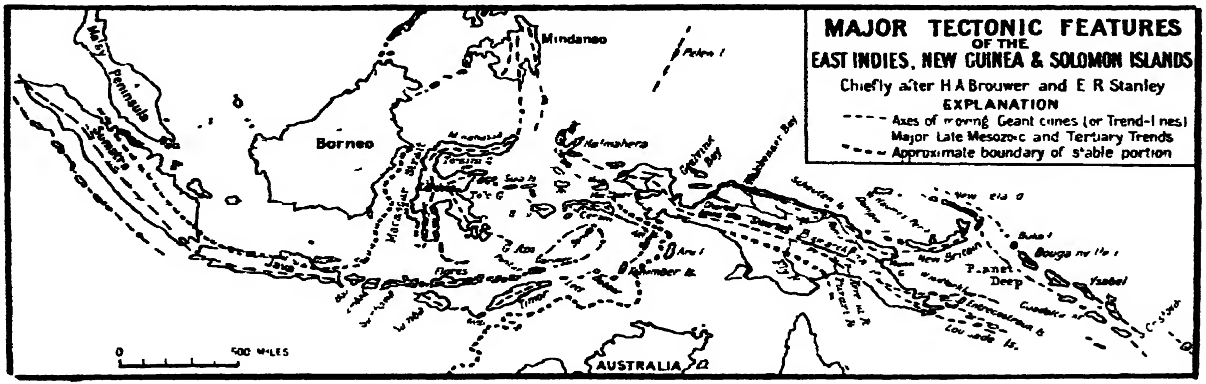

FIG. 2.—Major tectonic features of the East Indies, New Guinea, and Solomon Islands.

Australian continental massif. Thus the unstable, flexible, or geosynclinal region is compressed between the two continental massifs. Into this yielding area were concentrated the combined or antagonized effects of the circumpacific and Tethyan series of orogenic forces, and the great folding and fracturing in this region results from these forces. According to the views of Volz (1899), Richthofen (1900), and Ahlburg (1913), there has been formed a network of obliquely-intersecting tensional fractures, because the thrusts from the two continental masses exerted a screw-like torsion, acting in directions not actually opposed to one another. This is the view cited by Hobbs (1921); but the investigations of Wanner (1913, 1921), Molengraaff (1913, 1921), and Brouwer (1917, 1922) seem rather to indicate that the dislocations result from intense compression, with orogenic overthrusting or underthrusting at some depth and block-faulting at the surface, a view which is in part followed here.

The Asiatic portion of the Malay Archipelago consists of Sumatra, Java, Borneo, and the regions between them. The Mesozoic rocks are generally of shallow or moderately deep-water origin throughout, though in central Borneo what are held to be abyssal deposits are rather widespread. They are succeeded by a littoral or shallow-water type of Eocene beds with a fauna of a markedly uniform provincial character, and this faunal uniformity throughout the region has been maintained and strengthened up to the present day, and is illustrated, *e.g.*, by the similarity of the fishes in the rivers of north-eastern Sumatra and Java and of western Borneo, the valleys of which have been found to unite beneath the South China Sea, which covers a submerged peneplain (Molengraaff, 1921).* Crust-folding was relatively small in this region during Tertiary times. The whole area is ridged into a broad festoon of arcuate anticlinal folds, convex towards the south, and converging into a knot in the north-eastern portion of Borneo, and again in the north-western point of Sumatra (see figs. 1 and 2), whence the outermost of the anticlinal axes, which runs through the islands off the west coast of Sumatra, may be traced northward through the Nicobar and Andaman Islands into the Arakan Yoma. The chief folding occurred in Cretaceous times; the Permian, Triassic, Jurassic, and older Cretaceous strata are greatly disturbed, considerable overthrusting having occurred, and are invaded by plutonic rocks. Permian (?)† limestones are found superposed on Cretaceous sediments, or on Cretaceous granite, without any evidence of contact-metamorphism. The eroded surface of this complex is covered by Eocene littoral conglomerates and sandstone, with coal-measures followed by nummulitic limestone, Oligocene-Miocene foraminiferal limestones, and sandstone, on which lie unconformably younger Miocene marls and tuffs with Pliocene

* According to Molengraaff (*op. cit.*), this submergence was due to the general rise of the sea-level subsequent upon the melting of the extensive ice-sheets of the Pleistocene glacial period, a feature which Daly has discussed. The Sunda Sea is rarely more than 30 fathoms deep. In the absence of much definite information Molengraaff has suggested tentatively a like explanation for the Sahul Bank, which lies at about the same depth.

† Professor Wanner, however, has informed the writer (22nd May, 1923) that Van Es's correlation of the Palaeozoic limestones of northern Sumatra with the Permian formation of Timor, cited in the previous paper (Benson, 1923, p. 34), is not, in his opinion, supported by a sufficient faunal similarity, and Fliegel's determination of them as Upper Carboniferous should stand.

sandy claystones and lignites. Very important crust-warping and block-faulting occurred in Upper Pliocene times, which determined the form and position of the present coast-line, the raised coral-reefs, the main *graben* river-valleys, and many minor topographic features. The most marked of these *graben* extends almost throughout the length of Sumatra, and is separated by a relatively narrow range from the south-western coast. These latest structural lines often cross obliquely the older anticlinal axes, and are themselves intersected by many transverse and oblique fracture-lines, on which, as on the longitudinal fractures, there have been many points of volcanic eruptions.

Analogous conditions exist in Java. The area of exposed Cretaceous sediments and plutonic rocks invading older sediments is very limited. The varied nature of the Cainozoic sediments indicates that considerable geographic changes occurred during the Tertiary period. Verbeek and Fennema (1896) held that two unconformities occur, Oligocene-Miocene and Lower-Upper Miocene respectively. Tobler (cited by Van Es, 1917) holds that the greatest movement both here and in Sumatra was at the close of the Tertiary period, the folding preceding the deposition of the extensive Pleistocene sediments; but Van Es considers it was in progress during and after the Tertiary times.* It is more marked in the older central geanticlinal portion than in the younger flanking sediments, the steeper dip of the southerly-dipping beds indicating the southward (outward) direction of superficial thrust. The periods of greatest movement appear to him to have been in Miocene and post-Tertiary times. By the latter, Pleistocene coral-reefs have been raised as high as 2,500 ft., and the maximum uplift occurs where the Tertiary folding is most marked, the parallelism in location and direction being such as to indicate the intermittent action of a single group of forces of long duration. The outermost of the geanticlines is seen in the long submarine ridge rising to a depth of less than 1,000 fathoms, and separating an off-shore synclinal trough 1,500-2,000 fathoms deep from the foredeep over 3,000 fathoms deep. Continued to the west of Sumatra, however, this outermost geanticline rises above the surface to form a string of islands including the Mentawei Group.† As in Sumatra, so in Java, longitudinal, transverse, and diagonal fracturing was accompanied by block-faulting and volcanic eruptions at various times from middle Tertiary to the present date, and was instrumental in determining the present topography.

East of Java the main geanticlinal axis, with the volcanoes thereon, no longer forms a gently accentuated ridge marginal to a partially submerged plateau with the deep sea on one side only, but instead is a high and narrow ridge rising from considerable depths and broken by cross-fractures. It runs through Bali, Lombok, Sumbawa, Flores, and that string of islands, from Dammer to Banda and Gunong Api, forming the innermost of a series of discontinuous arcuate ridges separated by similarly interrupted troughs. The structure of this arc is not very clearly known, but,

* Martin (1919) states, however, that the recognition of the various subdivisions of the Tertiary rocks in Java has rarely been based on palæontologically satisfactory evidence, and the stratigraphical relationships of the several formations to one another are only exceptionally known. He therefore counsels caution in the acceptance of such generalizations as these.

† Molengraaff (1922) suggests that another anticlinal ridge existed still farther to the south-west, which has since subsided isostatically into the depths of the Indian Ocean, leaving Christmas Island as its sole representative above sea-level. Andrews (1900) has shown that this remnant consists of volcanic rocks and littoral calcareous formations, coral-reefs, &c., ranging in age from Oligocene to Recent.

at any rate in Sumba, between it and the outer arc there is no evidence of the occurrence of Miocene overthrusting. It is overlapped by an outer arc which, beginning at Savu, runs through Rotti, Timor, Letti, Babber, and the Tenimber Islands, and, according to the Dutch geologists, it continues thence by the Kei Islands to Ceram and Buru, though alternative conceptions have been entertained by other writers. Throughout this whole zone very extensive crust-movements have occurred and are still in progress.

While Suess's diagram (vol. 3, p. 235) of the trend-lines of the Philippine and Sunda Archipelago, "based on the writings of Drasche, Molengraaff, Hooze, Wichmann, Martin, Koto, and others," illustrates this conception of a continuous geanticlinal ridge, he was not himself convinced of its correctness, for he remarks as follows (vol. 3, p. 243): "It is in itself scarcely probable that the cordillera which comes from Sumba and Timor should reappear here [in Ceram and Buru] in full development after having been broken up into a series of small islands and reefs. I am therefore inclined to regard the arc of Timor as uniting with another independent chain striking east and west, and believe that Buru and Ceram should be looked upon as the continuation of the southern peninsula of [north-western] New Guinea." This view was supported in some degree by Boehm (1906) and lately by Gregory (1923, 1923A), and it must again be considered after the general structure of the Banda region as conceived by the Dutch geologists has been described.

Consideration will now be given to the outer arc and the Banda Sea, which whole region, according to Molengraaff (1921) and Brouwer (1917, 1922), illustrates conditions analogous to those which existed in the Alpine regions of Europe during Mesozoic and early Tertiary times. Brouwer's (1922) most recent statement may be cited: "The tectonic features of the East Indian Archipelago as they now exist are the result of orogenic forces which have been acting during long periods of time and have caused movements in a horizontal direction in many places. Where the lands were high above the strand-lines of the surrounding seas the ranges were cut down, and the deeper parts were uncovered by erosion; where at the same time the crust was moving below sea-level no denudation took place, and no unconformities and disconformities in the succession of strata are found. The latest crustal movements are only a younger stage and a direct continuation of the Tertiary crustal movements. The Tertiary folds and overthrusts, which were formed at relatively great depth, are now visible at the surface, but the fissured and faulted crust that once lay above them has been removed by erosion. On the other hand, the tectonic features due to late deformation near the earth's surface during the younger stages of mountain-building have remained visible, and are manifested in the fissured and faulted crust, while the accompanying folds and overthrusts remain invisible at greater depths. In the parts of the earth's crust now visible in the different islands the erosion-intervals are not found at the same place in the geological time-table. For the major tectonic features it is sufficient to describe the visible traces of two stages of crustal movements, the late Mesozoic and Tertiary stages, and the youngest stage, which still continues. The youngest stage is definitely known to be limited to certain parts of the present archipelago, while the distribution in time and place of the older stage is not definitely known." In the Alps the early Mesozoic formation and accentuation of anticlines and synclines was succeeded in Cretaceous times by strong horizontal movements, which "reached their maximum in the Tertiary period. As

the overthrust sheets moved at greater depth, the sea-basins became narrower, and the masses of the geanticlines were pushed forward in a nearly horizontal direction. . . . [Such] horizontal movements of the curving rows of [East Indian] islands are proved by several features now observable on these islands, and as these movements proceed the sea-basins will be narrowed, and eventually the masses of the present geanticlines may be pushed over the Sahul shelf of the Australian continent."

This may be illustrated by summarizing the stratigraphical succession and the tectonics of certain islands in this Banda arc. From Timor to south-western New Guinea the Permian sediments are of shallow-water origin, and are locally interstratified with basic igneous rocks. Probably much of the region was dry land in Permian times. In Timor the Permian sediments pass unbrokenly into Lower Triassic rocks, but the absence of the latter in other regions bears witness to a general marine regression of the sea in Lower Triassic times, followed by a very widespread Upper Triassic transgression. The sediments were largely of deep-water origin, being foraminiferal and radiolarian deposits, with some manganese-nodules, like those in modern abyssal ooze. These pass laterally into littoral formations, indicating diversified conditions of deposition on the synclines and anticlines of Upper Triassic times, the two facies of Triassic rocks being often brought into close apposition by the subsequent overthrusting. The Jurassic conditions resembled those of Upper Triassic times: the Jurassic sediments are partly those of deep-sea origin, but shallow-water deposits only occur in Misol and the Sula Islands. These general conditions continued up into Lower Cretaceous times, with apparently numerous local lacunae in the sequence of strata, the diversity of sedimentary facies resulting from the constant formation of geanticlinal ridges on which neritic sediments were deposited, and which were thrust forward along gently inclined planes of faulting at geosynclinal depths. These crust-movements were very marked in Cretaceous times, when the sea retreated from much of the present East Indian land-areas. The free connection between the eastern Australasian region and the Tethys was broken (Martin, 1914), and numerous plutonic intrusions were formed. It is difficult to state exactly the directions of strike of these late Mesozoic folds, for they have been greatly modified by the later Miocene orogeny. The orogenic stresses being temporarily relieved, a general subsidence occurred with the transgression of a shallow sea over Rotti, Timor, Letti, Ceram, and Buru, depositing Upper Cretaceous foraminiferal marls, accompanied by the formation of more littoral deposits in Celebes. This transgression was further extended in early Tertiary times, and the deposits formed were more diversified littoral conglomerates, sandstones, and clays predominating in the western part of the archipelago, foraminiferal limestones in the eastern, while associated with these in Bali, Sumbawa, Flores, and Sumba is a large amount of andesitic débris. The formation of the present deep-sea basins and other crust-movements began n Miocene times.

The older Tertiary rocks in Timor, and continuing thence into the Banda arc, have been intensely folded into a mountain-chain and overthrust outwards. The directions of these Middle Tertiary anticlinal axes are often oblique to the present coast-lines or the trend of the later Tertiary geanticlines. The phenomena of *klippen* (or, as the Dutch geologists prefer to call them, *fatus*, using the local Malayan term) are clearly developed: "Groups of deposits of the same age but of different palaeontological and petrographical character are found one on top of the

other, and isolated rock-masses of older formations are found resting on younger oceanic deposits: as is clearly visible among the deep ravines cut on the recently elevated islands, Timor and Babber. The structure is usually chaotic, and is similar to that of the higher overthrust sheets of eastern Switzerland, which were moved in the near-surface zone, where the rocks yielded to pressure not by flow, but mostly by fracture. The comparative method of study leads to the supposition that on Timor the deeper complicated but less chaotic overthrust structures such as are found in the Western Alps have not here been uncovered by erosion" (Brouwer).

There is, however, a marked variation in the intensity of disturbance. In Sumba there is no trace of overthrust-folding, and this forms the backland to the Timor zone of overthrust. Approaching the Australian foreland, also, the folding-structures in Timor are of somewhat simpler character, for the southern coast-range of this island has merely an imbricated structure with fairly uniform dip. The Aru Islands, believed by the Dutch geologists to be on the margin of the continental massif, form but a swelling thereon. They exhibit only Pleistocene (and Upper Pliocene?) marine limestones, &c.

Again, in north-western New Guinea north of MacCluer Gulf normally folded Tertiary rocks occur, as also in the Misol-Obi-Sula chain of islands, in which even the Jurassic strata, which are of shallow-water origin, are sometimes nearly horizontal, though locally sharp folding without overthrusting may occur (Boehm, 1906; Brouwer, 1921B). This region then seems to have been comparatively stable, and at least adjacent to a landmass during the Cretaceous and Tertiary periods of folding. The schistose pre-Jurassic rocks of the Sula Islands, the strike of which is markedly oblique to that of the Tertiary folds, may perhaps represent a portion of that ancient block. This block, thus relatively stable during the Cretaceous and Miocene foldings, seems to have been in some measure like a foreland to the great outward-moving superficial thrusts of the Miocene folding in Ceram. According to the views of the Dutch geologists, the strike of these folds is in the main the continuation of the Banda arc, but is complicated in regard to details. It is not parallel, but oblique, to the coast of this island, running south-east - north-west through middle and eastern Ceram, bending into an east-west direction in western Ceram, and inclining to the south-west into the terminal Huamoal Peninsula. These directions of strike are displayed both by the crystalline schist and gneisses along the southern side of the island, and the fossiliferous Triassic and later Mesozoic sediments along the north. Crossing Manipa Strait, however, the strike bends sharply to the north-west, as is shown by the schists of Manipa Island itself, and by the several zones of formations which cross Buru. These zones are, in succession from north-east to south-west, as follows: Crystalline schists, &c.; Triassic sandstones and shales; fossiliferous Triassic,* later Mesozoic, and early Cainozoic sediments; and they are therefore arranged in the opposite order, as regards the Banda Sea, to that displayed in Ceram. According to the Dutch geologists, there is an outward or northern thrust

* Professor Wanner has informed the writer (22nd May, 1923) that the supposed Upper Cretaceous molluscan fauna of Buru characterized by *Tissotia*, mentioned in the previous paper (Benson, 1923, p. 50), is really Upper Triassic (Noric), the characteristic form, when better specimens were examined by Krumbeck, having proved to be *Neotibetites*. The Upper Cretaceous form *Trigonosemus*, reported to have been found in Obi, is a Belgian shell, and was probably brought there by a Belgian prospector. Wanner himself found no trace of Cretaceous rocks in this island.

of the various formations in Buru as well as in Ceram; but this Wanner (1921) opposes, holding that in Buru the thrust was directed from the north-east towards the south-west. He compares this apparent reversal of the direction of thrust of a geanticlinal axis where a sharp kinking has occurred with the conditions on either side of the Straits of Sunda, believing, with Van Es (1917), that the direction of thrust in western Java is to the south; while, according to Tobler (1906), it was towards the north-east in the adjacent portions of Sumatra. According to a verbal communication made to the writer by Professor Brouwer, however, there is not a general acceptance of this conclusion of Tobler's. Wanner and Brouwer (1922) also suggest that the further continuation of the axis of Buru occurs in the neighbourhood of Sula Besi, the crystalline schists of which resemble those of Buru, and strike in a north-westerly direction, except for a single instance of an east-north-easterly strike which has been recorded, and he remarks that such a connection accords better with the zoogeographic evidence than the extension south-westwards to Tukang Besi, which Molengraaff (1921) has supposed might have existed.

Some comment may here be made on the rôle played by the Sula Islands, Obi, and Misol, which we have stated were in some measure like a foreland to the folds in Ceram, following Suess's conception, originally accepted by Wanner. As the result of continued investigation, Wanner (1921) now doubts the propriety of considering Misol at least as portion of a continental platform, for the moderately folded Mesozoic rocks which lie upon the crystalline rocks are similar in all essentials to the coeval formations that occur much more highly folded or even overthrust in Ceram*—so much so that they must be considered as having been deposited in the same geosynclinal depression. The relations of Misol to Ceram are indeed much more marked than its relation to Obi and the Sula Islands. It may be best to consider it as an outer portion of the geosyncline which has suffered relatively slight folding, rather than part of a foreland massif.

In attempting to trace the Miocene folding farther to the west the structure of Celebes must briefly be considered. This is a matter concerning which very diverse views have been expressed by Koto (1899), Sarasin (1912), Ahlburg (1913), Abendanon (1917), and others. According to Abendanon (1917), the whole region from south-eastern Asia to Tasmania in Palaeozoic times formed a single continental massif, which he termed "Aequinoctia." Thus he explained the apparent absence of pre-Permian marine fossils from the East Indies, though the occurrence of *Spirifera verneulii* (*S. disjuncta*) has recently been discovered in Celebes (Brouwer, 1919),† and may indicate the presence of Upper Devonian beds. There are widespread phyllitic rocks, possibly Palaeozoic, among the older formations invaded by the granites, &c. The presence of some such land-mass which would divide the stream of Asiatic forms migrating towards Australia might perhaps account for the difference between the later Palaeozoic faunas of the eastern and western regions of Australia noticeable in Devonian and Permian times (*cf.* Benson, 1923A, pp. 27, 31). Abendanon held that this land-mass was broken up in Carboniferous times, when an extensive submergence took place, and in the central region (now the

* A point of special interest to New Zealand geology is the occurrence in both Misol and Ceram of dark greywacke sandstones containing *Terebellina* ("*Torlessia*") *McKayi*, as noted by Wanner (1921).

† Some obscurely preserved brachiopods, &c., found recently in the north-western peninsula of New Guinea may be of like age, according to a verbal communication from Professor Brouwer.

Banda Sea) orogenic forces commenced to act, and have affected the region intermittently and more or less powerfully up to the present day. The present islands are considered by him to rest on disrupted fragments of this older platform, which, with their covering of Permian, Mesozoic, and older Tertiary rocks, have been greatly dislocated and folded during the subsequent orogenic epôchs. The crystalline schists and gneisses of Borneo, western and central Celebes, Buru, Ceram, and north-western New Guinea are held by him to be the exposed portions of this ancient platform, and he states that they exhibit a dominantly east-west strike varied to some extent by the post-Permian crust-movements.* Wanner (1919) is of the opinion, however, that the known instances of an east-west strike in the crystalline rocks of Celebes are far too few to establish definitely the existence of a pre-Miocene trend-line in this direction, and notes that the strike of the Miocene folding and the extension of the plutonic intrusions connected therewith (which frequently exhibit gneissic marginal facies) is usually in a north-westerly to north-north-westerly direction. Thus the trend of the Miocene folds in western, central, and south-eastern Celebes would appear to overlap, coulisse-like, the trend of the coeval folds in Buru. A like north-westerly or north-north-westerly strike is exhibited by the crystalline schists, &c., which form the base of the largely volcanic mass of the Minahassa Peninsula. In eastern Celebes strikes to the north-east have been noted in the slightly folded late Tertiary beds, but the main mass of the eastern peninsula consists, according to Wanner (1910), of massive horizontally-lying Eocene and Oligocene limestones, marls, and sandstones, locally upturned along a north-westerly strike. Here also Hotz (1913) has found grey-blue shales, containing belemnites, which resemble the Jurassic rocks of the Sula Islands. Thus the eastern arm of Celebes may perhaps form an outlying portion of the more stable region north of the zone of intense folds sweeping through Buru, south-eastern and central Celebes. It is noteworthy that basic intrusive rocks are particularly abundant in the margin of the folded rocks. A vast mass of peridotite occurs in south-eastern Celebes associated with diabasic rocks, and these extend to the north along the western side of the fault-bounded series of depressions extending through Tomori Bay from Tolo to Tomini Gulf These ultrabasic rocks were injected apparently during the late Mesozoic orogeny, and the late Cretaceous-Eocene marine sediments rest on their eroded surfaces, but there are, in addition, a series of Middle Tertiary intrusions of gabbros, &c.

The trend-lines of the Malay Archipelago are thus traced in accordance with Brouwer's (1922) charting (fig. 2). A point of detail should, however, be noted concerning the direction of the individual fold-axes. Brouwer (1922) points out that where the general trend of the geanticlinal zone is sharply bent, as in Babber, the individual fold-axes cross the main trend-direction almost perpendicularly. This is believed to result from differences in the amount of horizontal movement of the geanticline at depth and at the surface. The obliquity of the strike-line of the Mesozoic rocks of the Tenimber and Kei Islands to the direction assumed for the Banda arc in that region has had a very different interpretation, as will appear below.

* It is conceivable, however, as Professor Brouwer verbally indicated to the writer, that the crystalline schists of the region assumed by Abendanon to be the pre-Cambrian basement of the supposed Palaeozoic continent may be really the highly altered representatives of a long series of Palaeozoic geosynclinal sediments metamorphosed during the later Palaeozoic orogeny.

These orogenic movements were followed by long-continued denudation and widespread transgression of the sea, with the deposition of the petroliferous later Tertiary rocks, *Globigerina* limestones, and terriginous sediments, marls, clays, sandstones, and conglomerates, with increasing diversity of lithologic facies as the later Tertiary crust-movements became pronounced. These are succeeded by oyster-banks and (especially) coral-reef formations making a concordant series of deposits, followed, after further warping, by locally-widespread late Pliocene or Pleistocene reef-limestone, such as that which covered the greater part of Timor.

A considerable amount of volcanic activity occurred during the later Tertiary period, though it is not always easy to differentiate its products from those of earlier Tertiary age. Thus in south-western Celebes, "probably a short time before the deposition of the Tertiary limestone ('partly Eocene and partly Miocene') had completely terminated, eruptions began all along the western side . . . which gave rise to the high western mountains; for the greater part they consist of tuffs, breccias, volcanic conglomerates, of andesites, basalts, and also of leucite-rocks," while intrusive essexitic and shonkinitic rocks also occur. Farther north in the same island, however (the Latimodjong Range), the eruptions seem to have stopped before the newer Tertiary period. Leucitic rocks are also known to belong to the younger Tertiary formation in Sumbawa (Brouwer, 1917B).

The disposition of these formations renders clear the extent and nature of the Plio-Pleistocene crustal movements. The presence of uplifted fringing reefs is seen in nearly all the islands, where they sometimes form definite "reef-caps," the amount of the uplift being occasionally as much as 4,000 ft. "The uplift of islands has not, however, been simultaneous, nor equally intense, while periods of temporary subsidence have probably interrupted the general elevation since the Plio-Pleistocene period." The appearance of tilting presented in certain islands where raised coasts on one side of the island contrast with the subsidence observable on the other may not, however, really involve mere tilting of crust-blocks. Brouwer (1918) urges that in the forward wave-like propagation of a geanticlinal crest there would naturally be a depression on the rear slope of the crest related to the uplift on the forward limb, which depression might extend beyond the limits of that portion of the crest remaining above sea-level, thus giving rise not merely to differential uplift of the forward and rear coast-lines, but actually to features indicative of coastal drowning. Other things being equal, the greatest uplift will be seen in the widest islands. Thus in the case of Timor, which by the end of Pliocene times had been reduced by erosion to a cluster of low islands rising from a shallow shelf-sea, the sheet of reef-limestone then formed has since been arched upwards asymmetrically to a maximum height of 4,000 ft., contrasting thus with the arching that reaches a height of 1,300 ft. in the narrower island of Rotti, and only 460 ft. in Jamdena (the largest of the Tenimber Group). This group indicates another phenomenon. It consists of an eastern and a western portion, the former including Jamdena, and the latter a row of much smaller islands, in which, however, the elevated reef-caps stand at heights of up to 700 ft. This appears to result from the development of a small synclinal fold separating the two islands on the main geanticlinal ridge. The sharpness of this ridge is well marked at the Kei Islands, a short distance farther north, which rise between depths of 3,300 and 1,600 fathoms to the west and east respectively.

The main trend-lines of the later stage of mountain-making are now accurately known, and coincide approximately with the longer axes of the islands, while the deep-sea basins are found to be elongated arcuate synclines parallel to the adjoining rows of islands. The continuation of such movements is shown by the frequency of earthquake-shocks along the trend-lines, while they are notably absent from the stable region of eastern Sumatra, northern Java, Borneo, and the southern China Sea. A very noteworthy feature is the obliquity of the modern geanticlinal axes to the strike of the Tertiary folds, which want of parallelism Brouwer explains by the supposition "that the rows of uplifted and fragmented island-blocks indicate the places where at a greater depth folding continues, and that there is motion in a vertical direction as well as considerable motion in a horizontal one. The vertical movement will cause gradual erosion, and the exposed surface of the geanticline will in time consist of rocks which were in the zone of flow during an earlier stage of mountain-building. The rate and direction of the movement of the deeper-lying rocks as they approach the earth's surface may differ more and more from the rate and direction of motion of the rocks that lie at still greater depth."

Of noteworthy significance in connection with these movements is the distribution of the ancient and modern volcanic centres. During the recent crustal movements in the outer row of islands around the Banda Sea, where the crust has been thickened as a result of overthrusting, the magma has not reached the earth's surface, while the inner row, with a thinner crust, is characterized by a great number of volcanoes on the top of the geanticline. Where the two rows are nearest to one another, just now at Timor, there are no active volcanoes on the inner row, and the volcanoes on this row appear to have become extinct at a later and later period as their distance increases from this point and thus also from the stable Australian massif. The horizontal movements then progressively so increased the thickness of the crust in this zone as to stop up existing vents and prevent the formation of others. "We see in the inner row of islands of the south-eastern archipelago an instance of extinction of volcanic activity on the top of the geanticline during a renewal of the mountain-building process" (Brouwer, 1917).*

* It may be permissible to cite a few more sentences from this work (pp. 803-4): "If tangential pressure reveals itself in the formation of normal folds the molten magma will, under compression from all sides, force its way through the crust, with unequal strain first near the top of the anticlines where tension takes place. . . . In the case of disruption . . . the tension of the anticlinal and synclinal tops disappears or decreases, and the vents of the volcanic magma leading to the surface, maintained by the tension, can gradually be stopped up. Movements on a large scale will give rise to overthrust sheets, [and] the earth's crust *in situ* will increase in thickness, an additional reason for the stopping-up of the volcanic vent. A new way is opened for the magma to reach the surface along the thrust-planes. Most often the magma, if it reaches the surface, will appear on a lower level—*i.e.*, in the region here discussed, below the surface of the sea along the outer margin of the row of islands—and movements in the direction of the 'Vorland' will cause the volcanic products to be gradually overlain by the moving masses." In discussing the origin of the "green rocks" of the Alps and the older basic volcanic rocks of the Malay Archipelago the writer (Benson, 1924) independently put forward a view very similar to the above, adding that by the consolidation of the later drafts of basic magma rising along the thrust-plane, between the overthrust crust-flake above and the overridden submarine lavas below, there may be produced those intimate associations of gabbro-peridotite and pillow-lava that form so noteworthy a feature in the Mesozoic rocks of Switzerland—*e.g.*, in the Engadine—and in those of the Malay Archipelago.

The distinction here introduced between those parts of the archipelago in which the crust is still thin and those which have become thickened by overfolding recalls the new orogenic conceptions of R. T. Chamberlin (1919, 1921), who distinguishes between thick-shelled mountains (characterized by open gentle folding, a moderate crustal shortening affecting a relatively deep zone and strong uplift with vertical movement and normal faulting) and the contrasted thin-shelled mountains affected by intense deformation, leading to great overthrusting, especially in the marginal portions. Applying these conceptions to the eastern portion of the Malay Archipelago, it would seem as if the mid-Tertiary movements were characteristically of the thin-shelled type, and the overthrusting resulting therefrom thickened the crust sufficiently to cause the later movements to have more of the features of those in thick-shelled regions. The Plio-Pleistocene folds are broken by very many fractures. In opposition to Richthofen's view, cited by Ahlburg (1914) and Hobbs (1921), that these fractures result from tensional strains in a region nipped between the diversely thrusting Australian and Asiatic continental masses, Brouwer holds they are the surface expression of the vertical and horizontal movements which result from compressional stresses, and occur where there are important differences in the rate of movement in the underlying rock-masses if the fissures are approximately longitudinal, while transverse fractures result from a difference of velocity of horizontal movement in neighbouring parts of the geanticlinal axis. These fractures have broken across the geanticline, in many places separating the ridge into a number of separate islands. A very notable instance of this is the narrow Manipa Strait, over 2,000 fathoms deep, between Ceram and Buru. It occurs at a point of sharp flexure in the geanticlinal axis, which Brouwer (1921) points out should naturally be a point where fracturing might be expected owing to the differential movement of adjacent portions of the anticlinal ridge. Wanner (1921) accepts this view, and thinks it probable that the differential movement may here be measured in several tens of kilometres.

Among the regions hitherto discussed, however, it is in Celebes that the thick-shelled type of crust-movement is most in evidence. Here Plio-Pleistocene dislocations both in the region of crystalline rocks and elsewhere have formed a regular network of high mountain-blocks, which alternate with more or less depressed blocks in which are preserved the slightly-folded remnants of the formerly extensive covering of late Tertiary marine sediments, which were laid down on the submerged Middle Tertiary peneplain. The general direction of the main fracture-lines is approximately meridional, tending to the north-north-west, but these are crossed by an important series of east-west fractures, and by others with an approximately north-west trend. Ahlburg's (1914) map, reproduced by Hobbs (1921), indicates the position of these. By the fracturing and block-movement, the drainage system and the outline of the island have very largely been determined. On the western side, between Macassar Strait and the high ranges of crystalline rocks, there is a region of irregularly and often rather strongly folded Miocene sediments, with oil-bearing sandstones and shales and intercalated leucitic lavas, together with probably late Tertiary sandstones and conglomerates, which have a general north-easterly strike and are truncated obliquely by the coast-line. The crust-movements, indeed, have continued up to the present time, for Abendanon noted that a small plain had been uplifted not less than 16 ft. in the last fifty years (Wanner, 1919). The significance of this latest phase

of crust-movement in Celebes becomes greater when it is compared with the similar late Tertiary and Pleistocene movements in New Guinea and New Zealand.

It seems desirable here to note Professor Molengraaff's most recent generalizations (1922) concerning the tectonics of this region, as they show the manner in which Wegener's (1920) views have been applied to its explanation. (See also Wing Easton, 1921). Molengraaff holds that the arcs of the Malayan Archipelago originally formed a much more regularly curved series of arcuate folds concave towards Asia, of the structure of which they formed the marginal parts. On the basis of Tydeman's bathymetrical charts he would trace the easternmost anticlinal fold in Mindanao into the north-eastern arm of Celebes, and thence by the south-eastern arm into the Tukang Besi Islands, crossing a deep and narrow strait marked by sharp fracture and lateral dislocation of the anticlinal axis. He follows it from here with a sharp change in direction into Buru and Ceram, and thence by way of the Banda arc through Java and Sumatra into Burma, noting a certain resemblance between the occurrences of serpentine in south-eastern Celebes, Amboina, Moa, Letti, and Timor. Admittedly, however, the linking of the many diverse elements between Buru and the north-eastern peninsula of Celebes into a single anticlinal axis involves many difficulties, and does not commend itself to all the geologists who have studied this region. The suggestion is therefore put forward tentatively only.

Following Wegener's hypothesis, it is then supposed that Australia (inclusive of New Guinea) "moved horizontally in a westerly or north-westerly direction, and the portion of the arc between Buru and Rotti, and especially the particular stretch between East Timor and Buru, was gripped in the concavity of the coast-line (Arafura Bight)"—*i.e.*, the margin of the continental mass as indicated by the position of the hundred-fathom line. "Through this [movement] the folding arcs of the Moluccan geosyncline were thrust on to one another, so that one now sees that underthrusting directed outwards from the continent might act on the high islands of Ceram, Timor, Babber, &c., apparently like a system of overthrustings going out in a centrifugal direction from the central Banda Sea" (*cf.* Molengraaff, 1913). Thus the successive anticlinal ridges and deep synclinal troughs were wrinkled up in front of the advancing continent. In accordance with what has been said above, the kinks, transverse fractures, and dislocations of these anticlinal ridges are explained as the result of differential strains set up during their partial adjustment to the promontories and embayments of the coast-line of the continent of Australia.

Up to the present the conception of the Banda region entertained by the Dutch geologists has been followed, though Suess's objection thereto has been noted. Attention must now be called to Gregory's (1923) recent papers. After citing Suess's opinion and Boehm's general adherence thereto, he adds: "The geological evidence appears consistent with [this opinion]. The Tenimber Islands have been shown by Professor Brouwer to include vertical Mesozoic rocks, which he compares with those of East Ceram, but their strike varies from east-west to 28° north of west, and is therefore that of the island chain extending westward from Tenimber to Java, and is not due to folding on the lines of the Banda arc. In the Kei Islands also the strike of the older and more steeply tilted beds trends east and west (Verbeek, 1908, pl. xv, figs. 421, 431, 440), and is part of the general east-to-west grain of this region, and is older than the

Banda arc. It is true that in the Kei Islands there are some shallow folds which trend from south-south-west to north-north-east parallel to the eastern part of the Banda arc, but they may be explained by a gentle tilt towards the Banda subsidence, and they do not indicate a chain of fold-mountains. . . . The characteristic rocks of the Ceram-Buru line, and of the eastern end of the Timor chain, have not been recorded from the Kei Islands, which form the middle and essential part of the supposed Banda arc." He therefore concludes that "the evidence of the Banda arcs does not accord with the view that they are situated along a meridional mountain-range belonging to the Alpine-Himalayan system and connecting the Sunda and Buru-Ceram lines. The Kei Islands, the central part of the Banda arc, are built of materials that were deposited in the same basin as southern New Guinea. The foundation of these islands was folded in the late Eocene or Oligocene by the same meridional compression that formed the mountain-lines which occur both to the north and south of them, and extend past them both to east and west. This compression was part of the crustal movement which formed the mountains of the Alpine and Himalayan systems and also the fold-mountain chains of New Guinea. After the formation of the fold-mountain belt in the eastern part of the Eastern Archipelago, subsidences within it and fractures across it, similar to those frequent along the Alpine-Himalayan belt, happened in the Banda area. The subsidences formed the Banda and Weber Deeps, and cross-fractures broke up the land into islands and separated the Molucca Islands from New Guinea. These earth-movements, in accordance with the evidence so well interpreted by Professors Molengraaff and Brouwer, are probably still in progress; they have been very uneven, subsidence having occurred in one place while uplift was in progress elsewhere" (Gregory, 1923A).

In opposition to this conclusion may be cited the verbal comment of Professor Brouwer that as a result of laboratory investigation of his collections from Jamdena it now appears that much formerly assigned to the Tertiary should be relegated to the Mesozoic; and, considering the strike of these formations as well as of those previously held to be Mesozoic, it would appear that the balance of the very varying direction of strike lies more nearly meridional and in the direction of the Banda arc than at right angles thereto; and, further, the lines of strike shown by Professor Gregory running eastwards to east-south-eastwards through the peninsula south of MacCluer Gulf do not take note of the very sharply marked deflection to the south-east which actually occurs here, and appears to be concentric with the Banda arc, and to run thus for a short distance before bending back to the east-south-east along the line of the Snow Mountains.

In support of his view Gregory cites the comment of Suess (1908, p. 237) that "we might regard the whole zone of the Tenimber, Kei, and Watubele Islands, together with Ceram and Buru, as resting on an arc-shaped horst, and this would be separated on the north by a trough subsidence from New Guinea, Misol, and Obi"—though it is clear from a later remark (p. 243) his preference is to look on Ceram and Buru as the continuation of the southern peninsula of New Guinea, as does Professor Gregory. Professor David (1914) is cited in further support thus: "[Papua] is part of the Himalayan-Burmese arc prolonged through the Malay Peninsula, Sumatra, Java, and Timor. Its trend-lines are continuous with those of the Malay Peninsula [? Archipelago], and the

direction and age of the folding . . . agree with those of the Burmese arc." Kober (1921, p. 157) is also of the view that a uniform marginal chain runs around the Indian and Australian foreland from the Indus, through Timor and New Guinea, to New Caledonia, and terms it the Indo-Australian branch of the Mediterranean orogen. On his interpretation, the Sunda and Ceram-Buru chains would be respectively the outward-thrust lateral chains of a single but widened orogen, the central portion of which had subsided to form the Banda Sea, while New Guinea would represent the restricted portion of the same structure.

This diversity of interpretation of the structure of the eastern end of the Banda Sea naturally involves a corresponding variety of conceptions of the structural relationships of western New Guinea, to which attention must now be given. Converging towards north-western New Guinea are two arcuate lines of strongly folded mountains, the Buru-Ceram line already described and that running south-eastwards from Halmahera. The structure of this island, which Suess (1909, p. 308) assigned entirely to the Asiatic framework, is as yet but little known, but is perhaps essentially similar to that of Celebes, though the lesser elevation and dissection have not permitted the exposure of any crystalline schists in the foundation. So far as this is visible beneath the covering of late Tertiary and modern volcanic rocks, it consists of sharply upturned Tertiary and recently discovered Mesozoic sediments with infaulted pre-Tertiary basic igneous rocks (Wanner, 1913; Brouwer, 1922 and private communication). It seems to lie at the meeting-point of an Asiatic arc extending south-westwards from Yap and the Pelew Islands, with that running south-east into New Guinea. Between the latter and the Buru-Ceram arc is the resistant wedge made up by the crystalline rocks of eastern Celebes, the Sula Islands, and Obi, and the rather more yielding Misol mass. According to Brouwer's view, illustrated in fig. 2, the south-eastern Halmahera arc strikes across the southern peninsula of western New Guinea, and is here shown by steeply dipping Eocene *Alveolina* limestones, which appear to be drained by strike-streams, and bends round to the east and east-south-east into the Snow Mountains. It separates, therefore, the crystalline rocks of the Sula Islands from those of the northern peninsula of western New Guinea (the "Vogelkop") and the adjacent regions about Geelvinck Bay and farther east. In Suess's view the Buru-Ceram trend-line (though it may be locally deflected to the south-east in the southern peninsula) is continued into the Snow Mountains, while he groups into a single series not only the crystalline rocks of the Sula Islands, Obi, Misol, the northern peninsula, and Geelvinck Bay, which are overlain by nearly horizontal shallow-water marine Jurassic rocks, but also those which extend farther east, along the north coast and highlands of New Guinea as far as the Louisiade Islands, beyond its south-eastern extremity. Stanley (1921A) is of the opinion that the Halmahera arc swings into Waigeo Island, the northern peninsula, and Jappen Island, and thence extends along the north coastal ranges. On the view of Gregory (1923) it would seem as if the Snow Mountains and their eastward prolongation must be considered as a complete bilateral orogen, and to correspond with both the northward-thrust Ceram trend and the southward-thrust Timor trend, with a narrow central zone corresponding to the widened depression of the Banda Sea. No evidence yet advanced seems to indicate the existence of such an arrangement in

Ba'
ʋ.e Snow Mountains only, though the structure of the whole of New Guinea as viewed by Suess and Kober may approximate thereto.

There is, however, a very remarkable series of depressions which separate, by a trough-faulted zone twelve hundred miles long, a narrow strip of the northern-coast ranges from the great central ranges, throughout the whole length of the island. The relation of the topography of New Guinea to the Australian continental massif on the one hand and the Pacific Ocean on the other thus bears more than a passing resemblance to the relation of the topographic features of Sumatra to the stable Sunda region on the one hand and the Indian Ocean on the other, though this resemblance is lost as the eastern extremity is approached. The effect of east-and-west fault-lines in determining the direction of streams is seen in the headwaters of the rivers draining the northern Vogelkop Peninsula. The main rift-valley commences in the MacCluer Gulf, is continued by the valley of the Waiponga Stream draining westwards into Geelvinck Bay, and thence eastwards by the Rouffaer and Idenburg Rivers, which unite and enter the sea by way of the Mamberamo River, traversing the Van Rees Range. These two rivers have a flood-plain up to twenty miles in width at a height of about 160 ft. above the sea, and lie in a depression running for nearly five hundred miles parallel to the coast about eighty miles to the north. The headwaters of the Idenburg lie in a similar but smaller depression about sixty miles from the coast and seventy miles in length, and at an elevation of about 600 ft. Low gaps lead from these into the depression occupied by the Sepik (or Kaiserin Augusta) river-system, the broad alluvial plains of which cover elevated Pleistocene marine beds (Stanley, 1924). These depressions run approximately due east, but at the mouth of the last-named river opens another long trough depression, bounded by fault-scarps, which is occupied by the Ramu River, and leads across an indefinite divide, only 1,200 ft. above sea-level, into the Markham River valley, which opens into the Huon Gulf. On the north and south sides of this depression the Finisterre and Bismarck Ranges rise to heights of over 10,000 ft. In the valley itself somewhat dislocated late Tertiary or Pleistocene sandstones appear beneath the modern river-alluvium (Stanley, 1923). The southern fault-scarp of this depression continues for over three hundred miles to the south-east, forming the north coast of British Papua, and is recognizable in the truncated spurs of the various promontories, such as the Cape Vogel Peninsula. A series of volcanic rocks capping such promontories have been emitted along this line of fracture, and the active volcanoes of the D'Entrecasteaux Group may perhaps be considered as rising from a submarine extension of the Ramu-Markham zone of fracturing.

It will be best to describe separately the several structural zones of New Guinea from south to north. The lowland of southern New Guinea traversed by the Eiland, Digul, and Fly Rivers is composed of horizontal late Tertiary lignites and clays, through which appears the granite of Mabaduan, the outlying member of the series of granite-intrusions of Cape York Peninsula (Haddon, 1894). This is the stable portion of New Guinea, a portion of the Australian massif. Heldring (1909) suggested that this formed with the Arafura Sea and Gulf of Carpentaria an elliptical area of depression, the Gulf of Papua being a similar but more pronounced feature, and pointed to several features as evidence of such movements of depression, faulting, or warping; and David (1914) has entertained a similar view. Verbeek (*fide* Brouwer, 1917) doubted the validity of this evidence.

North of this lowland a series of step-faults have raised a terraced plateau of Pleistocene and probably Lower Miocene coral-limestones (occasionally traversed by basalt dykes) to an average height of 2,000 ft. above sea-level. These show the characteristically jagged surface of karst-lands (Staniforth Smith, 1912; Stanley, 1924A) The limestones occupy especially the regions about the middle course of the Fly River. Farther east the foothill region rises directly from the south coast of Papua. It is composed in part of pre-Miocene formations; contorted semi-crystalline grey or white limestones, which may be Eocene or Mesozoic; more or less silicified limestones with interbedded sediments; and the radiolarian cherts of the Port Moresby series, originally held to be Pliocene, but now considered pre-Miocene, though it lies apparently above the widespread Boioro grey limestone. Farther inland are sandstones with lignites which may be placed in this group. These are considerably crushed, folded, and faulted, and appear to have been overthrust towards Australia. They are succeeded unconformably by the Miocene-Pliocene petroliferous series —limestones, sandy marls, clays, grits, and sandstones with lignite, &c., volcanic agglomerates, and interstratified flows of andesite. Several minor unconformities appear to be present. The beds undulate, with a general south-easterly strike, but the lowest formations dip much more steeply than the uppermost. They are capped by raised coral-reefs along much of the coast. This foothill zone is succeeded to the north by the high ranges which form the backbone of New Guinea, and are known as the Charles Louis Range, the Snow Mountains, the Star Mountains, the Victor Emmanuel, the Bismarck, and the Owen Stanley Ranges, with various subordinate and spur ranges. In the western end of this central range are dark crinoidal limestones probably belonging to the Permian series, though farther south in the outer portions of the Snow Mountains are littoral Permian (?) sandstones (Heldring, 1911; Martin, 1911; Brouwer, 1917). The structure of the ranges has been investigated by Heldring and Hubrecht (1913). "There is a huge thickness of strata with a fairly uniform dip to the north over long distances, and it does not seem impossible that recumbent folds, imbricated structures, and overthrusts, with a movement directed towards Australia, may occur in these mountains" (Brouwer, 1922). The highest peaks, Carstenz and Wilhelmina Tops, rise to 15,000 ft. in height, and are composed of limestone, possibly Permian, rather than the later age previously assigned (*cf.* David, 1914), though the Eocene *Alveolina** limestone occurs. Crystalline rocks lie beneath these, and serpentines have been collected from the northern flanks of the range in the headwaters of the Rouffaer River (Gelder, 1910); and in the Setekwa, Eiland, and Digul Rivers to the south are pebbles of augite-granite, diorite, more or less gneissic gabbro, and also nepheline-syenite (Heldring, 1911).

In addition to these rocks there is a covering series of Middle Jurassic claystones represented by specimens from the river-pebbles in each of the main streams draining south from the Snow Mountains, and extending into Papua across the upper waters of the Fly and Strickland Rivers.

* The Eocene age of this limestone was originally determined by Martin (1881, 1911) and Schlumberger (1894). It was held by David to be Cretaceous, and a like view was accepted by Stanley up till the present year. Rutten (1914) has again pronounced it to be Eocene, and he is followed in this by R. B. Newton (1916, 1918), in whose papers the earlier work is fully discussed.

Cretaceous rocks are indicated by a usually unfossiliferous but occasionally belemite-bearing grey or blue limestone, which crosses the Purari River; the cherts with *Actinacis sumatraensis* at the junction of the Fly and Palmer Rivers; the fossiliferous sandstones and limestones on Korova Creek, near Kerema; and the ammonites, &c., in the calcareous shale in the Kerabi Valley, to which Dr. P. Marshall verbally assigned a Senonian age. A single development of Eocene coral is reported from the Fly River (Gregory and Trench, 1916). All these formations are stretched along the southern flanks of the great central range, which is essentially a horst, or faulted geanticline, consisting of crystalline rocks, the gneisses and schists of the Owen Stanley series. These are invaded by granitoid rocks, and porphyrites, and a long broken belt of serpentine, and upon them rest unconformably the phyllites, sandstones, and crystalline (Devonian ?) limestones of the Astrolabe-Kemp Welch series, which are invaded by fine-grained basic igneous rocks, and may be in part Palaeozoic. The cover of Eocene *Alveolina* limestone which probably extended over much of this complex has been almost entirely removed (see the generalized sections by Stanley, 1924). The extensive masses of limestone discovered by Detzner (1919) in the vicinity of the Bismarck Range south of the Ramu-Markham depression may be an important outlier of this formation, and be continued in the faulted masses capping the Saruvaged Ranges near the Finisterre Ranges to the north. The south-eastern extension of this central zone is, as previously indicated, bounded to the north by the faulted coast of Huon Gulf. There is a fringing, more or less undulating series of Miocene-Pliocene marine sediments resting on the ancient metamorphic rocks of the basement series, which are continued into the Louisiade Islands. Mount Victory, the only active volcano in Papua, is situated on this fault-line, and has built up the Cape Nelson Promontory.

The north-coast ranges of New Guinea extend north of the above-described longitudinal trench. The scattered data concerning them may be summarized as follows: In the west the northern Vogelkop Peninsula contains some highly dislocated rocks, in which have recently been found brachiopods and Mollusca, apparently of Palaeozoic (Devonian ?) age (*fide* Professor Brouwer). It is, however, difficult to separate these from the complex of crystalline schists and phyllites which make up the bulk of the peninsula and extend along the coast farther to the east. The Van Rees Mountains, as shown by Gelder (1910), consist of undulating late Tertiary lignite beds, sandstones, and marls, overlying older Tertiary nummulitic limestone, and perhaps Jura-Cretaceous rocks, as shown by the occurrence of pebbles containing *Perisphinctes* and *Inoceramus*. These are reported also at several localities farther to the east; and at Walckenaer Bay there are Miocene clays and coal-measures, which dip very steeply, while pebbles of various crystalline rocks in the river-beds near the coast indicate the presence of the basement series in the ranges they traverse. At Humboldt Bay, near the boundary between the Dutch and the mandated territory, the small island of Misotti is made up of serpentine (Suess, 1909, p. 306), while Miocene beds occur at Cape Djar on the mainland near by (Stanley, 1923). The north-western portion of the mandated territory has been studied by Richarz (1910), Reche (1913), and Schultze (1914), and consists of the Bougainville, Bewani, and Torricelli Ranges. On the southern slopes of the Bewani Ranges, drained by the Sepik River system, occurs the crystalline metamorphic series, together with an altered

group of phyllites, slates, and conglomerates, with chloritic and epidotized diabases, and porphyrites and keratophyre-tuffs invaded by gabbro and diorite. The Bougainville Range is largely made up of the Oenake serpentine massif. Overlying these older rocks there occur fossiliferous Jurassic sediments in the headwaters of the Sepik and October Rivers, Cretaceous foraminiferal limestones, also older Tertiary (?) glauconitic sandstones and shales invaded by gabbro on the southern slopes of the Bewani Range, with nummulitic and lepidocyclinal limestone, which dips south-south-east at 10°, on the northern slopes. Farther east, in the Torricelli Mountains, are fossiliferous sediments which were referred by Richarz to the Cretaceous period, but which must be considered Lower Miocene (*fide* Wanner, private communication) on account of the occurrence of *Lepidocyclina* and other Foraminifera. These dip at 80° 85° to the north-north-west, a marked local variation from the general strike. These last are followed by the semi-indurated limestones, sandstones, and grits near Monumbo (Potsdamhafen), which dip north-eastwards at 25° 30°, and appear to have been invaded by granodiorite, as is again the case in other points along the coast (Stanley, 1923, p. 24). These rest on older basalts, and overlie unconformably a series of phyllites, &c. (comparable with the Astrolabe - Kemp Welch series), which have been invaded by a large mass of pre-Tertiary peridotite. This series of shattered and metamorphosed sedimentary rocks makes up the coastal Adelbert Range, running hence to Madang (Friedrich Wilhelm Hafen), and is capped here and there by andesite. At the back of it lies the Ramu depression. A similar series of ancient schists, &c., invaded by basic plutonic rocks forms the foundation of the Finisterre Range and the Huon Peninsula. It is reported that the strike here swings from a south-easterly into a easterly direction, though caution must be exercised in deducing the strike of a very dislocated series of rocks from the general elongation of the fault-bounded horst in which they are exposed. Capping the Saruvaged Range at a height of 13,000 ft., and forming the highest portion of the peninsula, are the extensive faulted masses of white limestone discovered by Detzner (1919): this may be, as Stanley (1921) has suggested, an extension of the *Alveolina* limestone which is so widespread farther to the west. Nearer the coast the ancient rocks are covered locally by approximately horizontal carbonaceous sandstone and volcanic agglomerate. Suess notes the abundance of andesites here.

Throughout the whole extent of the northern coast of New Guinea there are very frequent instances of upraised Pleistocene marine deposits and coral reefs.

Summarizing the stratigraphy of New Guinea as deduced from the available data, there must first be recognized an ancient gneissic and schistose group of rocks, together with a somewhat younger but highly disturbed series of sediments and volcanic rocks, possibly in part Palaeozoic. These have been invaded by granites, and especially basic plutonic rocks and peridotites. They are succeeded, probably uncomformably, by Permian, Jurassic, and Cretaceous rocks, the relations of which to one another are not yet clear, though there is as yet no evidence of marked orogeny during the Mesozoic period. Nor, indeed, is there yet any proof of important crust-folding between the time of deposition of these and that of the early Tertiary sediments, littoral sandstones, siliceous radiolarian cherts, and the very extensive Eocene *Alveolina* limestone which covered the greater part of the area, though there seems evidence of some minor

unconformities between the successive members of this series. During Oligocene-Miocene times, however, strong movement occurred at several points along the north coast, accompanied by the intrusion of granodioritic rocks, and the general direction of superficial thrust of the older Tertiary beds appears to have been northward along the north coast, but southward towards Australia along the southern side of the central range. The older Tertiary beds are unconformably overlain by the Miocene-Pliocene oil-bearing series of sandy marls, grits, and limestones, with volcanic agglomerates and andesite, these later Tertiary formations occurring on both sides of the axis. Extensive block-faulting and warping occurred intermittently throughout the later Tertiary period, producing minor interformational unconformities, and was accompanied by volcanic eruptions, which on the north coast and on the south-east extend to the present day. Planation occurred to some extent during the pauses between the successive crust-movements, and in particular the Mesozoic and early Tertiary covering-rocks were removed from a large part of the central horst region, which had been elevated to some extent before the deposition of the later Tertiary rocks. The post-Tertiary movements were, however, particularly great. The central ranges were elevated as a vast concourse of earth-blocks, with huge scarps, such as that of Mount Suckling, in eastern New Guinea, which faces to the north and is 8,000 ft. high, or the southward-facing scarps of Mount Leonard Darwin and Carstenz Top, in the Snow Mountains, which are estimated to be over 10,000 ft. high—"the most stupendous precipice anywhere in the world" (David, 1914). The lesser displacements near the coast have raised Pleistocene reefs to a height of 2,500 ft.

Preliminary accounts of the course of the structural or trend lines have been given by Suess, Sir Edgeworth David (1914), and Stanley (1921), who has prepared a more extensive discussion (Stanley, 1924A), which the writer has been permitted to consult. According to the former, the main trend runs from west to east through Dutch New Guinea, bending round to pass south-east into the Louisiades, with a probable virgation by way of the Finisterre Range into New Britain. "This strongly marked Burmese trend-line is crossed by minor trend-lines, subordinate folds and faults, more or less meridional, coming from Australia. . . It may be suggested very tentatively that the mainland of Australia has functioned as a 'foreland massif'; Torres Straits, the Gulf of Carpentaria, and the deep Mesozoic and Tertiary basins, with their thick strata, as a senkungsfeld. Possibly the crystalline schists forming the greater part of the backbone of the island have played the part of an inner or 'ruckland massif,' which has helped to roll up the Mesozoic and Tertiary sediments. The chief fracture-zones on which the present active volcanoes of Mounts Victory and Dobu are situated appear to lie on the inner limb of the fold-region, just the portions which have been put in tension as the result of the southerly creep of the Papuan area towards Australia" (David, 1914). Stanley (1920, 1921) added to this view the hypothesis of a further and trident virgation in the south-eastern promontory. The outermost branch runs through Woodlark Island (Murua), and the bathymetrical chart of Groll (1912) suggests that Rennell Island, an elevated atoll probably covering a volcanic cone (Deck, 1921), and perhaps the Loyalty Islands east of New Caledonia, may be a continuation of this trend-line. The intermediate and inner branches consist of the D'Entrecasteaux and Louisiade Islands respectively. In all three branches are ancient schists,

and plutonic rocks associated with indurated slates, grey limestones,* sandstone, and conglomerate on Woodlark Island. On this foundation folded Miocene limestones rest. The whole D'Entrecasteaux Group appears formerly to have been united to New Guinea, and to have been separated therefrom and subdivided by east-west rifts accompanied by volcanic activity, and followed by meridional rifting and renewed vulcanicity. In both Woodlark Island and the Louisiades raised and tilted coral-reefs are a characteristic feature (Stanley, 1912, 1915).†

In regard to the trend-lines of the north coast and the Finisterre Ranges (the Tertiary and Mesozoic rocks in which Suess considered "the outer boundary of the folded range which immediately succeeds them to the south"), Stanley (1923) no longer considers them as a portion of the same tectonic zone as the main ranges of the island, but, following a suggestion made by Suess, views them as a separate geanticline "of smaller dimensions, with a probable Asiatic structure, and thereby related to Halmahera, the Philippines, and Japan. This coastal feature is modified by faults or steep folds, which cut obliquely the geanticlinal axis" (*cf.* Suess, 1909, p. 308). This axis, he believes, bends eastwards in the Huon Peninsula, and extends into New Britain (Stanley, 1921a). Parallel to it runs a line of active volcanic islands (the Schouten Group) from beyond the mouth of the Sepik River across Dampier Strait, and this is continued by the great series of volcanoes along the northern coast of New Britain. Kober's view, on the other hand, seems to regard the north-coast ranges as forming the northward-thrust lateral portion of a single orogen comprising the whole of the highlands of New Guinea.

The south-eastern portion of New Guinea thus affords several interesting problems. Suess (1909) groups the whole of this island series, together with New Britain, the Solomons, New Hebrides, New Caledonia, and northern New Zealand, into a single great system, which he terms "the first Australian arc," recognizing, however, an inner and an outer portion. The former, which includes the whole of New Guinea and the islands off the south-eastern extremity, may perhaps be considered to be represented also in New Caledonia; the latter is that containing the Bismarck Archipelago, the Solomons, and New Hebrides. As held by various writers, especially David, Andrews, and Jensen, whose views were summarized in a previous paper (Benson, 1923), Australia grew generally from the south-west towards the north-east and east. It appears in accord with this that the modern crustal activity, both seismic and volcanic, is very marked in the outer portion of the arc, and to a less degree in the inner, and then only near the recently fractured areas of New Guinea, away from which, both to the east and to the west, such activity diminishes. There seems, indeed, reason for recognizing, as Stanley does (1921), two distinct arcs—the outer fairly continuous, broken only by narrow transverse subsidences, the inner very discontinuous and largely submerged. The precise rôle of New Britain is, however, almost as indefinite as that of the Kei Islands, though even if it be no more than an arcuate horst it cannot be considered as exactly analogous with the Kei Islands. As will appear, however, it does seem to be much more probable that it is a definitely folded arc.

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* The strike of this limestone is N. 20° E., or approximately at right angles to the general trend of the line, probably indicating a strong local flexure adjacent to a cross-fault.

† For a recent detailed account of the coral-reefs of these islands, based for the most part on a study of the British Admiralty charts, see Davis, 1922.

The structure of New Britain has recently been summarized by Reed (1921) and Stanley (1923, 1924). On the inner northern side of the arcuate island the sea reaches a depth of 1,400 fathoms, but on the outer plunges steeply down into a narrow trough over 4,000 fathoms deep. There is a core of schists and gneisses invaded by granodiorites and syenite, gabbroid rocks, with diabases and porphyrites. These are associated with Cretaceous (?) grey-white limestone containing *Acteonella*, possibly, however, to be correlated with that occurring on the Purari River (Papua), and other crystalline limestones in New Ireland and the Solomon Islands. There are also steeply dipping older Miocene sediments, overlain unconformably by gently folded Pliocene series of foraminiferal sediments and tuffs. The volcanic eruptions seem to fall into three chief epochs, the first dating back to the close of Miocene time. These periods appear to have significance for the whole of the eastern New Guinea and the adjacent archipelago. Stanley (1924) remarks: "The first phases were associated with the main tectonic zones of faulting, which were more or less parallel to the axis of folding The second phase was conterminous with subsequent strand-folding, which I consider represented the maximum period of movement in late Tertiary times. The third or final stage is partly connected with the second or coastal fractures, and really commenced as these movements were becoming less in the second set; but these later eruptions are due principally to a second set of fractures—namely, a series of north-and-south rifts, more or less at right angles to the coast-line, which are well in evidence throughout New Britain, and to a lesser extent in the islands of the D'Entrecasteaux Group." An especially good example of this is seen in the Willaumez Peninsula, projecting northwards from the centre of New Britain. The modern volcanic activity is thus greatest along the north coast of this island, and, as has been noted, it extends thence in an arc westwards to the Dampier and Schouten Islands along the north coast of New Guinea. To the north-east the strike swings round into parallelism with that of New Ireland, which runs from north-west to south-east.

In New Ireland, according to Schubert's observations, cited by Stanley (1923), together with those of Sapper and Lauterbach (1910), there is a basement series of gneiss and grey crystalline limestone invaded by plutonic rocks ranging in acidity from granites to gabbros. Diorites are also found in the islands in St. George's Channel between New Britain and New Ireland, and in New Hanover to the north-west of the latter. They are overlain by older volcanic rocks, Miocene-Pliocene foraminiferal limestone, &c., and raised coral-limestones, with abundant Recent volcanic rocks. The presence here of an old folded cordillera is quite clear, and it may be traced from the Admiralty Islands, where ancient rocks have been found beneath modern volcanic accumulations (*fide* Stanley), through New Hanover and New Ireland, in which the strike bends sharply from south-east to due south. This geanticline appears to have subsided for three hundred miles thence to the south-east, but may be recognized again in the south-western islands of the Solomon Group—namely, New Georgia, Gaudalcanar (Gera), and San Christoval. This southernmost island of the group seems to be the meeting-point of two or three slightly diverging geanticlinal ridges, which together make the outer portion of the major structure termed "the first Australian arc" by Suess. The innermost or western member of the three is that which has just been described; the central member runs through the

northern and eastern portion of the Solomon Islands, Florida, Ysabel, Choiseul, Bougainville, Buka, and thence along the volcanic islands of the Namatanai chain a short distance east and north of New Ireland and New Hanover, and terminating in St. Matthias Island (Mussau); while the outermost branch may be represented by the shorter ridge diverging northwards from Malaita to the coral-islands of Ontong Java. The cordilleran nature of the Namatanai ridge is shown by the occurrence of diorite in Tabar, one of its constituent islands.

In regard to the structure of the Solomon Islands, little can be added here to Suess's (1909) account of this group. According to Stanley (1923), the latest phase of volcanic activity is represented in Buka and Bougainville Islands; and in Poperang, a small island immediately south of the latter, there is a grey crystalline limestone containing *Rhynchonella*, which Suess thinks may possibly be Mesozoic. In Ysabel, diallage-serpentine is known, and schistose serpentine and granulite in Florida Island. In Gaudalcanar, andesite, dolerite, and porphyry occur, besides Recent volcanic rocks, peridotite, gabbro, serpentine, and a grey slickensided (possibly Mesozoic) limestone. San Christoval is very clearly a portion of an ancient cordillera which has been uplifted after planation. "The mountains are arranged in parallel series of long flat-topped ridges." The island is extensively composed of ancient igneous rocks: diorites, sometimes gneissic gabbros, saussuritic feldspar rocks, and diallage rock serpentine are known, together with indurated slaty rocks and quartzite. Cassiterite has been observed in one stream (*cf.* Marshall, 1912). Diallagic serpentine is also known in Santa Anna, the most southerly member of the group. A series of active volcanoes stand, so far as can be seen, between the isolated remains of this cordillera, and probably rise from portions which have subsided between transverse fractures. In many places the islands are surrounded by coral-reefs elevated to as much as 500 ft., fairly uniform displacements being traceable for nearly four hundred miles (*cf.* Guppy, 1887).

The arc of the Solomon Islands is separated by a deep transverse depression from that of the New Hebrides. Mawson (1905) was unable to confirm the existence of gneissic rocks in the latter, previously reported by Levat, but gave interesting particulars concerning the Tertiary and later history of this island group. An arching of the sea-floor in Miocene times permitted the formation of shallow-water limestones, which were brought above sea-level as the elevation continued, and were invaded by andesite sills. The steep westerly dip of the limestone suggests that the superficial thrust was in the direction of Australia. Fracture and subsidence, especially of the eastern limb of the anticline, were accompanied by the outpouring of basalt and the formation of unfolded Pliocene and Pleistocene foraminiferal tuffs capped by differentially elevated coral-reefs, reaching a maximum height of 2,000 ft. above sea-level in the northern part of the group. This island group does not, however, represent a single simple anticline running to the south-south-east, but, somewhat as in the Solomon Islands, it branches at Efaté (Sandwich Island) in the middle of the group, sending off to the north a series of volcanic islands including active vents. These are not present in the larger islands of the north-north-westerly or main chain of the group, a further instance, possibly, of the easterly retreat from the Australian nucleus of the zones of maximum crustal activity, though the whole region is still unstable. Mawson recognized that this differential elevation of the various islands,

FIG. 3.—Bathymetrical map based on data assembled by Sieberg, Marshall, Groll, and J. K. Davis. Structural features of eastern Australia after David's map.

though superficially one of block-faulting, is essentially a continuation of the Miocene orogeny, and that cross-faulting "of the blatter type," and volcanic eruption, have led to the present distribution and structure of the island masses.

Seismological investigation shows that the crust-movements are still in progress in the outer arc. To the east of the New Hebrides the sea-floor slopes comparatively gently to a depth of 2,000 fathoms, but to the west it sinks rapidly to a depth of 4,490 fathoms (fig. 3), so that the ridge is strongly asymmetric, its steeper slope facing towards Australia, or, more immediately, New Caledonia, from which it is separated by a deep narrow trough. Brouwer's conceptions would lead us to expect here the presence of overfolding at great depth, thrusting almost horizontally south-westwards into a foredeep. In agreement with this is the record of over a decade of seismological observation made by the Rev. E. F. Pigot at Riverview College, Sydney, to whose courtesy the writer is indebted for permission to cite the following unpublished generalizations. The New Hebridean ridge is a region of much seismicity, and the great majority of earthquake-epicentres are situated on the western slope of the ridge, the one facing the deep trough. Moreover, the formation of cross-faults is clearly indicated by the grouping of certain earthquake-epicentres along lines transverse to the main geanticlinal axis. This seismic zone may be traced north-westwards along the western slope of the New Hebrides-Solomon Island ridge, where it plunges down into the Planet Deep, which is apparently the foredeep of the outer and still-growing member of Suess's first Australian arc. Thence it passes through New Britain into New Guinea, and westward through this last island into the Charles Louis Range. It is in northern New Guinea that the seismic activity of this belt reaches its maximum, and here it is apparent that the first Australian arc presses most closely on to the Australian continental massif. Brouwer (1921A), citing, *inter alia*, Visser's work, has remarked on the extension of this zone farther westward into the Moluccas. As in the New Hebrides, the chief epicentres are under water, and lie on the steep slope leading down from the southern coasts of Sumatra and Java into the foredeep which separates the orogenic zone from the submerged portion of Gondwanaland. The movements are there along longitudinal tectonic lines, but in addition there are many shocks occurring along transverse lines, especially in regions where older folds are cut off by the present coast-lines.

Return may now be made to the inner portion of the first Australian arc, consisting of the south-eastern extremity of New Guinea and the adjacent islands, which have already been described, and New Caledonia and the Loyalty Islands. The Loyalty Islands are separated from New Caledonia by a narrow trough, in places more than 1,000 fathoms deep. The islands are elevated and slightly tilted coral reefs, showing several stages of uplift, and nowhere rising more than 400 ft. above the sea. In the island of Marè, around which five terraces are recognized, a small core of volcanic rock is exposed, which suggests that the other islands in the chain are reef-masses covering a string of volcanoes built up from eruptions along a single tectonic line (Davis, 1915). Stanley (1921) has suggested that this is the line which forms the outermost member of the virgation in the south-east of New Guinea, and that it continues through Woodlark Island by way, it has been herein suggested, of Rennell Island. The southernmost of the Loyalty Islands, Walpole Island, is also ringed by

five raised reef-terraces (Andrews, 1922), and is of especial interest because of the recent discovery on it of remains of the giant fresh-water tortoise *Miolania*, now being studied by Dr. C. Anderson. This is also represented, though by a different species, in Lord Howe Island, as will be seen later.

The structure of New Caledonia is decidedly complex, and the account given by Suess (based chiefly on the writings of Peletan, Reurteau, Glasser, Deprat, and Piroutet) may be replaced by a summary of Piroutet's (1917) more recent studies. The island falls into two approximately equal portions, the boundary of which is about the line of latitude 21° 15′ south. In each the eastern coast is steep, the land rising into high ranges, while on the west the relief is more gentle, and low hills and plains occur. In the northern portion the ancient crystalline rocks, gneisses, mica- or glaucophane-schists, and less-altered possibly Palaeozoic sericite-schists and quartzites, are arranged in an arcuate fold concave towards the north-east, the strike swinging from nearly N.-S. in the north-western extremity of the island to E.-W. and even E.N.E.-W.S.W., where it meets almost perpendicularly the central portion of the eastern coast of the island. West of these ancient rocks, in the northern half of the island, and in the southern half also, the Permian, Mesozoic, and Lower Tertiary rocks are bent into folds striking much more nearly parallel with the general N.W.-S.E. axis of the island, though numerous departures from this direction, especially two south-westwardly concave arcuate folds. are considered by Piroutet to indicate the presence of relatively rigid blocks of ancient folded rocks concealed beneath the younger Mesozoic and Tertiary formations. Brouwer's interpretation of analogous features may be recalled. Some deflections also may be due to the entry of the vast instrusive masses of ultrabasic rocks. The sedimentary rocks bear witness to continued geographic changes, with intermittent folding or warping, erosion and deposition, from Permian to Recent times, accounting for the many lacunae in the stratigraphical succession. A Permian transgression passed westward over this region, depositing littoral and rather deeper-water sediments. A regression commenced during Lower Triassic times, the marine sediments of this age being sparsely developed, and the crust-movements leading to a complete withdrawal of the sea in Middle Triassic times were associated with or preceded by basaltic eruptions. Depression followed irregularly in Upper Triassic times with a widespread transgression of the sea, followed by a complete retreat of the sea at the close of the period, the region being dry land during the Rhaetic and the greater part of the Jurassic period. These renewed movements were accompanied by further basaltic eruptions. In late Jurassic times a further subsidence took place, when the sea flowed in from the south-west to the centre of the island, depositing Tithonian and early Cretaceous sediments, the latter interstratified with rhyolites and andesites. Before this, however, a certain amount of crust-folding or warping occurred along axes oblique to that of the pre-Permian folding. Up to this time the successive faunas were all closely related to Malayan and Tethyan faunas in general, with some circumpacific elements, but now significant changes took place Reason has been adduced for a slight modification of Piroutet's (1917) account of the Cretaceous succession (Benson, 1923); but he nevertheless shows that some crust-folding occurred during the middle part of this period, the intensity of which does not appear to have been very great. The direction of the fold-axes is stated to be oblique to the strike of the Jurassic and the Permian folds. This folding was succeeded by the entry from the east of a Senonian marine transgression,

which penetrated into regions in which the Lower Cretaceous deposits are lacking. The new immigrant fauna was distinctly of the Indo-Pacific type, and apparently had a definitely marked affinity with that of New Zealand and the American Antarctic regions, though its detailed description is not yet available. The deposition of these Senonian beds was followed by great crustal instability and frequent oscillation, producing a variety of sediments, conglomerates, sandstones, foraminiferal and algal limestones, gypsiferous clays, &c., associated with basic tuffs, basalts, dolerites, &c., abundant in the higher members of the Eocene series, in which several minor unconformities are recognizable. The coastal connection with New Zealand appears to have broken down, there being no community of Eocene marine fauna, though the continuance of connections with the north-west is indicated by the New Guinea, Malayan, and Asiatic relations of the species of Foraminifera which occur in the New Caledonian Eocene beds,* but are unrepresented in New Zealand. These are, however, the latest of the Tertiary deposits of this island. Their formation was followed by the greatest orogeny which is displayed clearly in the island, in which the superficial thrust, coming from the north-east, is again directed towards the Australian nucleus, as in the case of the other regions of mid-Tertiary folding. Though the overthrusting is not developed as extensively as in Timor, the Permian beds in certain areas are thrust above the Upper Triassic, and the Mesozoic above the Tertiary, though not as extensively as Suess supposed (following Glasser's (1903 4) account), (fig. 4). In some regions, perhaps those buttressed by subjacent relatively rigid masses of older folded rocks, the Tertiary folds are more or less symmetrical, but along the east coast a series of subsidences permitted the development of back-folding, the folds being frequently overturned towards the north-east adjacent to that coast.

Besides the three well-defined periods of folding noted, minor crust-movements may have occurred at other periods, especially at the close of Lower Triassic times and in the Middle Eocene. The last great movement of approximately Miocene age was accompanied by the injection into the crust of vast amounts of ultrabasic magma, which is now exposed in large or small masses of peridotite throughout the island.

Concerning the subsequent movements of the crust little detailed information is available to the writer. Coral-reefs, raised from 6 ft. to 20 ft., surround the island, and in general there seems to be a slight tilting movement in progress, a subsidence in the partially drowned western coast, and (at least in earlier Pleistocene times) an elevation on the eastern. This is further exemplified by the uplift of the coral-limestone of the Isle of Pines in the south-eastern extremity (Compton, 1917), and of the Loyalty Islands still farther to the east. This elevation Andrews (1922) believes to be due to Recent crust-movements independent of and more vigorous than those of New Caledonia. Thus the whole New Caledonian ridge can

* As the list of the Eocene fossils of New Caledonia is not readily accessible in New Zealand, it may be useful to give it here, as compiled from the work of Deprat (1905) and Piroutet (1917). The forms marked with an asterisk (and possibly others also) are known in the Eocene rocks of New Guinea and the Malay Archipelago: *Orthophragmina* cf. *chudeaui*,* *O. discus*, *O. dispansa*,* *O. javana* var. *minor*,* *O. lanceolata*, *O.* cf. *multiplicata*, *O. nummulitica*?, *O. pentagonalis*, *O.* cf. *pratti*, *O.* cf. *sella*,* *O. stella*, *O. stellata*, *O. umbilicata*,* *O.* cf. *varians*, *Nummulites baguelensis*,* *N. nanggoulini*,* *N. jogjakartae*,* *N. striatus*, *N. variolarius-herberti*; also various species of *Alveolina*, *Discocyclina*, *Miliola (Pentellina)*, and *Operculina*, together with some bryozoa, *Prenaster* cf. *alpinus*, *Spatangus*, and *Lithothamnium nummulitica*.

be considered in the main as a geanticline which has been developing intermittently from Permian times, the diverse strikes of the successive foldings resulting, probably, from the apposition of the folds formed at the surface in strata lying on the eroded surface of those formed at depth. Further, though active orogenic movement has ceased, a slight warping of the ridge is still in progress. The foundering of the north-eastern coast may suggest the occurrence of block-movements in association with the Tertiary folding; but Davis (1918) is of the opinion that the generally rectilinear, cliffed yet embayed, north-eastern coast is not a fault coast, but has resulted from an extensive and very recent submergence of a series of wave-cut cliffs formed after an earlier period of long-continued emergence. No late Tertiary or Recent volcanic activity has been recorded in connection with these crust-movements.

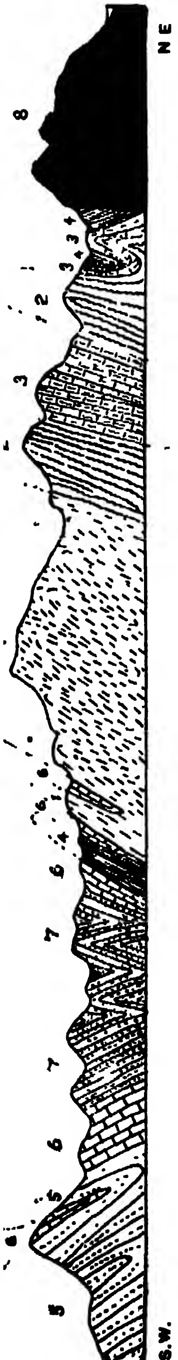

FIG. 4.—Section across New Caledonia (after Piroutet, 1917). 1, sericite-schists; 2, quartz-schist and phyllites; 3, Permo-Triassic; 4, Upper Jurassic-Cretaceous coal-measures; 5, Middle Eocene; 6, 7, older and younger Upper Eocene; 8, serpentine.

It is now possible to contrast the structure of the Australasian margin as displayed on either side of New Guinea. Though Kober (1921) has classed the whole into a single orogen, and Gregory (1923A) has supported in some degree his conception of the Banda region as a bilaterally outthrust structure with a subsided central zone, it is by no means clear that such an arrangement is continued into the central ranges of New Guinea, as Gregory suggests in his diagram, and the actually observed trend-lines in the western portion of that island do not accord with the suggestion that might be raised by Suess's phrasing that New Guinea as a whole, with its outthrust coastal ranges and longitudinal depression, should be regarded as the continuation of the Banda structures. Still further difference is seen to the south-west, where (omitting New Britain), in place of a bilateral arrangement, the structure is that of a series of parallel unilateral chains, running concentrically about the Australian nucleus and superficially thrust in that direction. It might perhaps be argued that the deep west of the Solomon-New Hebrides chain is not a true foredeep, as its seismic characters would indicate, but essentially the subsided central portion of the orogen towards which the eastern flank has been turned back, while in the normal case the thrusting would have been in the opposite direction—*i.e.*, to the north-east—symmetrically with the south-westerly thrusting of New Caledonia. In support of this view might be cited the overturning of the folds in the east of New Caledonia itself towards this depression, which Piroutet (1917) has pointed out. The alternative suggestion that the deep is a true foredeep, and the New Hebrides-Solomon ridge is but the marginal fold of the former continent now represented by the

submerged platform which rises above the sea in the Fiji Islands, would seem to remove that ridge from the tectonic control of the Australasian structure rather more than would be in accord with the conceptions entertained by Suess and Andrews (1922). Further divergencies from the Moluccan type of structure of the Australasian margin will be seen below in the account of New Zealand, where the folded arc passes into a more or less continental platform.

Passing farther to the south, it is noted that the New Caledonian-Loyalty Island ridge is not continued far beneath the ocean, but is cut off by a depression between 1,000 and 1,500 fathoms in depth, beyond which, but some distance west of the prolongation of the New Caledonian axis, the Norfolk ridge rises to within 500 fathoms of the sea-surface, and continues with a slightly sinuous but generally south-south-easterly direction towards the centre of the North Island of New Zealand, meeting it to the west of the short submarine prolongation of the North Auckland Peninsula. The basaltic mass of Norfolk Island, rising from this ridge, contains a volcanic tuff with fragmental crystal-grains possibly derived from a plutonic source (Speight, 1913). Stretching west of the narrow New Caledonian trench is a large submarine plateau, situated at a depth of less than 1,000 fathoms, reaching almost to the coastal shelf of Queensland, from which it is separated by a deep, narrow trench. From this a second wider and more continuous ridge extends south-south-easterly to the neighbourhood of Cook Strait. Lord Howe Island (composed of relatively ancient and probably late Tertiary basalts and agglomerates) rises from the western side of this long submarine plateau-ridge, which is separated from the Norfolk ridge by the New Caledonian trench, between 2,000 and 3,000 fathoms deep; and a like depth, the Thompson Trough, divides it from Australia. The special interest attaching to Lord Howe Island lies in the occurrence in it of the remains of the giant tortoise *Miolania*, which is also known in the Pleistocene rocks of Walpole Island, of Queensland, and Cretaceous (?) of Patagonia. "As *Miolania* must have been a land-animal, its discovery in regions so remote is sometimes cited as one proof of the former existence of a great Antarctic continent uniting the lands in question."* This, and the position of the broad suboceanic ridges, suggest a continuance of a general south-south-easterly grain in the structure of the floor of the Tasman Sea, which may thus be the foundered former continental land. Such an indication, however, clearly does not approximate to a proof.

The geological formations of New Zealand may be classed broadly into a pre-Cretaceous and a Middle Cretaceous-Tertiary series. The following tectonic details concerning it may now be noted. The most ancient rocks are visible along the western slopes of the South Island. According to recent ideas, they are crystalline schists and gneisses lying unconformably below the Ordovician sediment; but the possibility that they are (partly at least) an extremely altered facies of the Ordovician rocks cannot be held to have been excluded. Their strike is very variable, ranging from W.N.W. to N.N.E., and is not noticeably different from the strike of the Ordovician rocks. Its varying trend is possibly due to the refolding along approximately meridional lines of rocks originally folded on a north-westerly strike. A limited area of Silurian sediments also

* *British Museum Guide to the Fossil Reptiles, &c.*

occurs, but their structural relationships are not clearly known, though their strike appears in general to be approximately parallel to that of the Ordovician beds. The earlier north-westerly folding was accompanied by the intrusion of more or less gneissic granites according to Park (1921), who has revived the belief that this occurred in Devonian times. By some writers the intrusion of the gneissic diorites has been assigned to this period, but recent work shows that a much later date is probable. The relation of the older Palaeozoic to the later Palaeozoic and Mesozoic sediments which presumably rest unconformably on them is not clearly exhibited. At one time these later rocks were classed into one continuous series (Maitai series) of supposedly Trias-Jura age, but they are now known to range from the Permian to basal Cretaceous, and to contain several lacunae and probably disconformities. These were the littoral sediments on the western margin of the Pacific of that period. Diversity exists in the interpretation of the structure of these rocks. It has been affirmed (on grounds the writer considers inadequate) that an extensive orogeny, accompanied by the intrusion of the gneissic diorites of the south-west, occurred between Permian and Triassic time, but, though, as Marshall has now recognized (1917A), some break may occur here, which would account for the absence of the Lower and Middle Triassic fauna, no angular conformity has been shown between the two series, and probably a simple retreat of the sea, to be correlated with the general regression throughout the Malay Archipelago in Lower Triassic times and resulting disconformity of Upper Triassic on Permian or basal Triassic annelid beds, was the essential feature of that interval. Indeed, it may have been partly bridged by the time of deposition of the large series of unfossiliferous greywackes which intervene between the two fossiliferous formations.

The gently undulating Jurassic beds of eastern Southland certainly contrast sharply with the steeply folded Maitai rocks of western Southland, but do not come into contact with them. Instead, they pass down conformably into the strongly folded Triassic rocks of the Hokonui Hills, which, when traced to the north-west, could scarcely be separated by Hutton from the Maitai rocks of western Southland; and, though he returned (1885, 1900) to his first impression that there was a concealed unconformity here, he believed for a time (1875) that a perfect conformity existed. The strike of these beds in the southern flank of the Hokonui Hills is towards the north-west, but, as was shown by Cox (1878), it bends very sharply but continuously round into a southerly direction parallel to the strike of the Maitai rocks of western Southland, and thus encloses a wedge-shaped area of gently undulating Mesozoic sediments which cover much of south-eastern Southland. The significance of this will be discussed later. On the northern side of the Hokonui Hills the fossiliferous Triassic rocks appear to pass down into the flat-lying micaceous schists of Central Otago, to which further reference must be made.

The early Cretaceous orogeny is the most marked of the tectonic disturbances which have affected New Zealand and produced very intense folding and dislocation. The strike of the Permian, Triassic, and Jurassic rocks varies considerably, though chiefly within the same limits as those of the older folded strata. The variability is most marked in the shattered earth-blocks in the north-western peninsula in the North Island. Approximately meridional strikes, varying somewhat to the east or west, are common in the main ranges of this Island, and the plication

is most intense in the eastern half, though without extensive overfolding; but on the western side it is more open, and the strata are undulating except where they are shattered by the broad crush-zones as shown by the recent investigations of Henderson and Ongley (1923). The same trend continues through the Kaikoura Mountains of the South Island, though a north-easterly strike is marked near the line of separation between the Palaeozoic rocks in the north-western portion of that Island and the Permian to Mesozoic rocks which make up the Southern Alps. Mr. Morgan (1911) has suggested that here the north-easterly-striking Mesozoic rocks have been thrust over the north-north-westerly-striking Palaeozoic foreland. A zone of shattering invaded by plutonic rocks sometimes separates the two masses. The ultrabasic rocks of the Dun Mountains, and the gneissic granodiorites of the south-west, appear to have been erupted at this period, proof of the intrusion of the granodiorite into the annelid-bearing Permian or Triassic sediments having recently been obtained by Moir and also by Park (1921).

In the southern half of the South Island of New Zealand the main ranges bifurcate. One branch, containing the Palaeozoic sediments and granodiorites, continues to the south-south-west through Fiordland, bending later to the south-east into Stewart Island; the other range bends directly to the south-east, running through Central Otago, and consists of the problematical Otago schists. These form a broad anticlinal mass of sericitic schist, usually appearing to pass laterally and vertically into fossiliferous Permian (?) and Triassic greywackes, &c., though rectilinearly bounded masses of greywacke appear to be sometimes rather sharply distinct from the adjacent schists. On the south-west boundary of Otago a syncline (largely covered by Recent alluvium) and a sharp anticline of fossiliferous Triassic greywackes (forming the Hokonui Hills) separate this region of nearly flat schists from the gently undulating unaltered Mesozoic sediments of Southland, which are wedged in between the two branches of the bifurcating range, as indicated above. Suess terms this bifurcation the meeting of two unilateral chains in syntaxis; but the writer would suggest that it resembles rather a virgation of a single range with a general westward superficial thrust forced by the presence of a rigid block underlying the gently undulating Mesozoic strata. In the north of the Hokonui Hills the gradual passage of the greywacke into the schist, and the complete absence from the greywackes of any detritus derived from the schists on which they rest, as demonstrated by Marshall (1912, 1918), inclines the writer to Marshall's view that the schists are but the metamorphosed form of the greywacke. In the Otago region, as has been suggested by Wilckens (1917), the superficial thrust seems to have been so great as to produce overfolding, so that the flat-lying schists may really be a packet of recumbent folds. This explanation was also independently conceived by the writer (Benson, 1921), with the addition that the Hokonui anticline was considered as a Parma-like forefold separating the overfolded area from the resistant massif beneath Southland; and, further, the existence of fault-blocks bringing the slightly altered upper recumbent folds down among the lower folds and more metamorphosed rocks was suggested as a means of explanation of the occurrence of rectilinearly and rather sharply bounded areas of greywacke among the micaceous schists. The lack of recognizable horizons, however, will long prevent the adequate testing of these hypotheses. It is to be noted that plutonic intrusions are almost entirely absent from the region

supposed to consist of recumbent folds, but they are abundant in the western branch of the forced virgation — *i.e.*, western Southland and Fiordland.

It may here be remarked that according to Hector (1870), cited by Marshall (1912), the schists of the Chatham Island may be compared and correlated with those of Otago, and have a north-easterly strike; and remnants of a large area of crystalline rocks presumably united into single massif occur in the other islands scattered south-east of New Zealand.*

Authorities have differed concerning the continuity or otherwise of the sequence of late Cretaceous and Tertiary "Notocene" strata which rest on the eroded surface of the late Mesozoic folds. The difficulties attending the solution of this question are particularly great in the North Auckland region, owing to the paucity of recognizable horizons and the dislocation and discontinuity of outcrop of the several formations resulting from the plexus of Pleistocene fractures. Among the lowest of the Notocene strata are marly beds with a Senonian fauna, now under investigation by Dr. Marshall, and apparently comparable with those in New Caledonia, the South Island of New Zealand, Graham Land, and Chile. Newer than these and more widespread are foraminiferal and algal hydraulic limestones, probably for the most part of about Danian age—though it is not at all certain that all the lithologically similar masses of limestone here are coeval. These are followed by tufaceous sandstones with Mollusca, some coal-measures, and a polyzoan limestone of possibly Oligocene-Miocene age, which form the chief distinctive formations in a great thickness of clay or marl above the hydraulic limestone (*cf.* Ferrar, 1922). In addition to these, however, are several interstratified bands of conglomerate, the character of the pebbles in which is being studied by Mr. J. A. Bartrum, and is yielding very significant information, which by his courtesy the writer is permitted to discuss here. As far back as 1884 McKay noticed the intrusion of ultrabasic rock into the hydraulic limestone. This Bartrum has confirmed, finding several instances of masses of normal serpentine, troctolite, or gabbro invading the limestone. The intrusion of such plutonic rocks is characteristically associated with orogenic crust-movements (*cf.* Benson, 1924), so that it may be inferred that the same was true here. Among the above-mentioned conglomerates, however, Bartrum found pebbles of ultrabasic and basic rocks, suggesting that extensive erosion followed the post-Danian orogenic movements before the deposition of the conglomerates and associated claystones, &c.† Thus by a new line of attack upon the obscure stratigraphy of the region the occurrence of a marked unconformity in the Tertiary record in the North Auckland region is seen to be extremely probable; and this unconformity may tentatively be correlated with the much more extensive and vigorous Tertiary orogeny and plutonic intrusion in New Caledonia, and that of the overthrusting in the East Indies, which, as we saw, decreased greatly in intensity when traced

* Observations made by R. S. Allan while these notes were in the press show that the general strike of the schists of Chatham Island runs but little north of due east, though there are exceptional north-easterly, meridional, and even north-north-westerly strikes, apparently in regions of local dislocation. The strike of the schists here is thus approximately parallel to the direction of extension of the shallow bank connecting the Chatham Islands with the mainland. The direction as shown on fig. 3 must thus be modified. The overlying Tertiary marine sediments and volcanic rocks do not appear to show any marked folding.

† The source of the bulk of these pebbles, however, he believes to have been a pressure-affected "terrain which was in existence before and during the deposition of Trias-Jura sediments." (*Cf.* Bartrum, 1924.)

north-westwards into Sumatra. It is, as yet, quite impossible to indicate the direction of superficial thrust of these crust-movements in New Zealand. The dips of the Tertiary rocks are generally moderate (30°-40°), and the strike is so variable in orientation that it is difficult to pronounce any direction as being that of the prevalent strike. Crust-movement appears to have continued intermittently throughout the Gisborne district (Henderson and Ongley, 1920) during the Cretaceous and Tertiary period, and recently Ongley and Macpherson, during their official geological survey of the East Cape district, have found that the Crétaceous rocks are very strongly folded with a north-west-south-east strike, and are invaded by a pre-Miocene dioritic complex, the source, perhaps, of the dioritic pebbles in the basal conglomerates of the Miocene beds of the Gisborne district. In Hawke's Bay McKay (1877) recorded the occurrence of strongly folded Cretaceous rocks beneath the gently undulating Pliocene beds, and this has been confirmed by Dr. Thomson, who (in a private communication) has compared the Cretaceous rocks lithologically with those of the Middle Cretaceous (Clarentian series) of the South Island. With them he would include the "East Coast series" formerly referred tentatively to the Lower Cretaceous by Morgan (1915) and the writer (1921), and considered to be the latest of that great series of Mesozoic sediments laid down before the Cretaceous orogeny, though the relationship of this series to the characteristic, highly dislocated, and definitely pre-Cretaceous greywackes and argillites has not yet been critically examined. Again, in Palliser Bay, east of Wellington, McKay (1879) recorded the presence of vertically dipping Amuri (Upper Cretaceous) limestone lying unconformably beneath Tertiary marine beds, and Thomson observed pebbles of Cretaceous rocks in the Upper Tertiary sediments in the same region. In the South Island there is as yet no clear evidence of an early Tertiary orogeny, though warpings and block-movements during the period seem to have caused small angular unconformities, disconformities, and overlaps' in different localities, not apparently confined to any one period, though probably most pronounced in the early Tertiary and Pliocene periods. The gradually accumulating evidence for these has been summarized by Vaughan (1921) and the writer (Benson, 1921). A few examples of extremely localized overfolding of Tertiary rocks, as at Nelson and on Lake Wakatipu, may be local thrustings connected with the Plio-Pleistocene block-movements.

In Pleistocene times this crust-warping and block-faulting with tilting were extremely important, and were the chief processes by which the present topography was determined. The nature of these movements has been elucidated by Professor Cotton in a succession of important papers (*e.g.*, 1916, 1917, &c.). The chief system of longitudinal fractures and warpings is of those which run north-north-east to north-east, cutting obliquely across the strike of the Mesozoic folds. They have in many regions blocked out the main features of the coast-lines, subsequently modified by the normal processes of marine erosion, so that the strike-ridges meet the coast *en echelon*. In the south, however, where the trend-line of the Otago schists bends to the south-east, the coast truncates the trend-lines almost perpendicularly. The volcanic zone in the centre of the North Island is continued in the same north-easterly direction to White Island, in the Bay of Plenty, and thence into the Kermadec ridge, the origin of which is thus bound up with the structural development of New Zealand. Besides this main longitudinal direction of fracturing there are minor diagonal or transverse fractures and warpings in certain regions.

Since this late Tertiary and Pleistocene climax of block-movement of the crust extensive erosion has taken place; the covering of Cretaceous and Tertiary sediments on the harder pre-Cretaceous greywackes, &c., offering relatively little resistance, has, for the most part, been removed from the higher blocks, but remains in the relatively depressed coastal lowlands, and also in a series of intermontane basins, where it may be covered by the fluviatile gravels derived from the highlands (Cotton, *op. cit.*; Speight, 1915). This recalls in a striking manner the main topographic features of Celebes described above. The latest crust-movements have been in the nature of broad regional warpings, depression or uplift moving equally aggregates of many of the smaller fault-bounded blocks, producing features of coastal drowning or elevation, with consequent revival of river-valleys. The origins of the earthquakes felt in New Zealand (with a few exceptions *e.g.*, the Cheviot earthquake and the recent Taupo, Wellington, and North Canterbury shocks) are situated not within the land area, but some distance seaward to the east (Hogben, 1914, 1918).

In a previous paper (Benson, 1923, pp. 10–12) the tectonic relationship of New Zealand and Antarctica has been discussed, and support given to the view of Mawson (1911), Gregory (1912), Wilckens (1917), and Kober (1921) that the continuation of the south-easterly trend-lines of Otago will be found in King Edward VII Land and Graham Land, and form part of the folded margin of the Pacific Ocean basin, the continuity of which in Upper Cretaceous times is indicated by an extremely uniform littoral Senonian fauna. In furtherance of this it may be pointed out that there seems a marked similarity in age and petrographical character between the largely dioritic, more or less gneissic rocks of south-western New Zealand and the granodioritic batholiths that are so characteristic of the Antarctandes of Graham Land, the Andes proper, and the coast ranges of British Columbia. Since Upper Cretaceous times, however, the bordering land-masses of this oceanic littoral have been broken up by fracture-systems, the most marked of which, in the New Zealand region, cross the old trend-lines obliquely, running in a north-north-easterly to north-easterly direction. To these may be ascribed the blocking-out of the subsided region forming Ross Sea, and the shaping of the general outline of New Zealand, excluding that of the North Auckland Peninsula, which is due to other fracture-systems. On this conception the New Zealand-Kermadec ridge would appear rather more as a complex fault-horst rising from an extensive submerged platform than as a fold-anticline. Brouwer, however, points out that a geanticline growing at depth is represented at the surface by a fractured ridge, often marked by a line of volcanoes, and separated from a foredeep by a steep submarine slope beneath which earthquakes originate. These are features exhibited to some extent by the Kermadec ridge and Tongan trough, from which the lines of volcanic and seismic activity may be traced respectively southwards into the centre, and off the east coast of the North Island of New Zealand. If New Zealand be regarded as the apex of a virgation, it appears to have become more or less stabilized and continental in character in the broad, largely submerged southern portion, the scanty information concerning the structure of which was summarized in a preceding paper (Benson, 1923, p. 11). The crustal activity increases northwards into the separate arcs. Andrews (1922, p. 20) remarks that the arcs become continental and confluent at their southern extremity. This appears to have been the case also at an earlier epoch, for the evidence of crust-movement during early

Tertiary times in the South Island is much less marked than in the North, where even plutonic intrusion appears to have occurred; and thence follows the immense folding and intrusion of peridotite during the same period in New Caledonia, and the general occurrence of Tertiary orogeny and plutonic intrusion along the zone traced all the way to Timor and its adjacent islands. In much of this, however, the evidence for Cretaceous orogeny and plutonic intrusion is less definite than it is beyond the regions mentioned—namely, in Java and Sumatra at the one extreme, and in the South Island of New Zealand at the other—into which the Tertiary orogeny did not extend. Again, though late Tertiary and Pleistocene crust-movement (block-faulting) accompanied by volcanic and seismic activity extending up into modern times occurs more or less markedly throughout the whole zone, it apparently reaches its maximum in the central region from the New Hebrides to beyond New Guinea, in which last the displacements have been very great indeed. Thus throughout the course of time there seems to have been a progressive limiting of the region of maximum intensity of crustal activities to the area where—to use Andrews's (1922) phrase—the Tethyan and Pacific controls most directly interact. Possibly the diversity of the structure of the Australasian margin, which, as has been pointed out, exists between the western and eastern sides of this central region, arises from some diversity in the nature of these controls, the one a compression between the Australian and Asiatic continental systems, and the other between the Australian region and the Pacific floor. In the latter the effect has been to produce a continuously outgrowing complex, as emphasized especially in Andrews's papers, in which the modern volcanic and seismic activity in the New Hebrides is but the continuation of the action of the same controls which produced the Tertiary orogeny and plutonic intrusion in New Caledonia, and the successive zones of Permian, Carboniferous, Devonian, and early Palaeozoic folding and plutonic intrusion which may be traced in south-westerly sequence through the eastern States of Australia.

In conclusion, the writer has pleasure in acknowledging his indebtedness to several friends for help in connection with the preparation of this paper. Professor Wanner communicated some useful comments on the previous paper and minor corrections. Professor Brouwer kindly read the portion of the manuscript dealing with the East Indies, and made very valuable suggestions. Dr. S. van Valkenburg, of the East Indian Topographic Survey, provided some useful maps, especially the large new "Schetskaart van Nieuw Guinee (Nederlandsch Gebied)." Mr. Stanley, Government Geologist of Papua, discussed many points, and placed at the writer's disposal a large amount of unpublished material, including the manuscript of his forthcoming *Geology of Papua*, and a shorter paper since published by the Australasian Association for the Advancement of Science. The Rev. E. F. Pigot contributed seismic data from the New Hebrides - New Guinea area; Mr. J. A. Bartrum, unpublished information concerning the Tertiary intrusive rocks of the North Auckland Peninsula; Messrs. Ongley and Macpherson, information concerning those of the East Cape district, Dr. Allan Thomson, information concerning the Cretaceous rocks of Hawke's Bay, and Mr. R. S. Allan, observations recently made by him in the Chatham Islands. Mr. G. E. Harris has assisted in the preparation of the diagrams. To all these gentlemen the writer's thanks are due. He desires especially to acknowledge his debt to Professor Sir Edgeworth David, who first aroused his interest in the fascinating problems which have herein been considered.

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On a New Species of Epitonium.

By A. W. B. Powell.

[*Read before the Auckland Institute, 14th December, 1922; received by Editor, 28th December, 1922; issued separately, 26th May, 1924.*]

Plate 5.

While collecting specimens of *Epitonium jukesianum, philippinarum,* and *zelebori* at Mount Maunganui, Bay of Plenty, Dr. Bucknill noticed another species that was quite distinct. Suter mentions in the *Manual of the New Zealand Mollusca* that a white variety of *Epitonium tenellum* is sometimes found. No doubt this species is the one referred to, but a closer examination reveals the presence of microscopic spiral striations and various points of difference from the other species of the genus. *Epitonium zelebori* also possesses spiral sculpture, but belongs to the section "*Cirsotrema* Moerch," characterized by the distinct spiral keel, prominent spiral ribs, and denticulate axial ribs, so cannot be confused with this new example, which is a true *Epitonium*.

A few weeks after the discovery of the species at Mount Maunganui Mr. La Roche, of Auckland, found seven specimens of the shell at Whangaroa. That a shell of this size had escaped notice so long, and was then found in two widely separated localities almost simultaneously, is remarkable, and serves to show that there is still much to be accomplished before the knowledge of our molluscan fauna nears completion.

The author has great pleasure in uniting with the species the name of its discoverer. Thanks are also due to Mr. La Roche for his invaluable assistance.

Epitonium bucknilli n. sp.

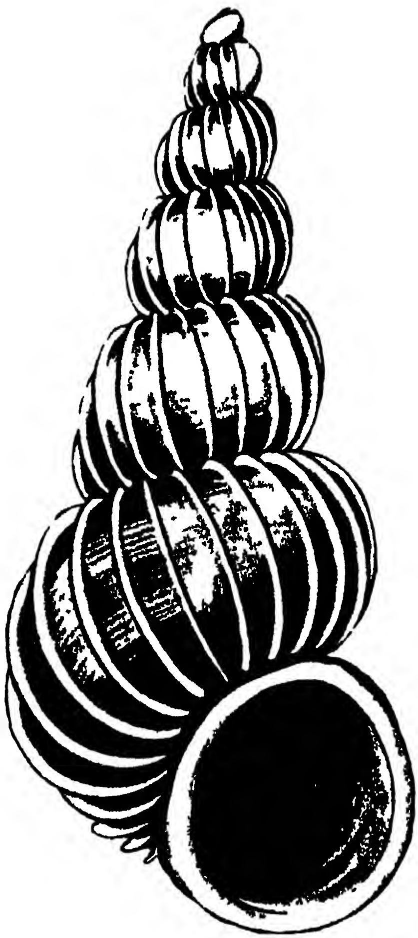
Shell of moderate size, semitransparent, imperforate, thin and fragile. Sculpture consists of arcuate lamellar axial ribs, discontinuous over the whorls, 16 to 20 on last whorl. The type has 20 ribs on last whorl; interstices with microscopic spiral striations. Colour pure white. Spire elevated, conic, about 2½ times the height of aperture; outlines straight. Protoconch small, of 2 smooth convex whorls. Whorls 7, convex, a little separated, not shouldered; base convex. Suture deep. Aperture oblique oval. Peristome continuous, thickened by an axial rib, very slightly expanded at base. Columella short, oblique, slightly arcuate. Inner lip slightly rounded with free and sharp margin. Operculum unknown.

Diameter, 7 mm.; height, 16·5 mm.; angle of spire, 30° (type). Average specimen: Diameter, 5 mm.; height, 11·5 mm.

Animal unknown.

Habitat: Mount Maunganui, Bay of Plenty; Taupo Bay, Whangaroa; Kaitoke, Great Barrier Island.

Material: The holotype in the author's collection, Auckland. Six paratypes were obtained at Mount Maunganui, twenty specimens at Whangaroa, and one at Great Barrier Island.



Epitonium bucknilli n. sp. 7 mm. × 16.5 mm.

Face p. 138.]

The Geology of the Riverhead-Kaukapakapa District, Waitemata County, Auckland.

By J. A. BARTRUM, Auckland University College.

[*Read before the Auckland Institute, 19th December, 1922; received by Editor, 31st December, 1922; issued separately, 26th May, 1924.*]

Plate 6.

CONTENTS.

INTRODUCTION.

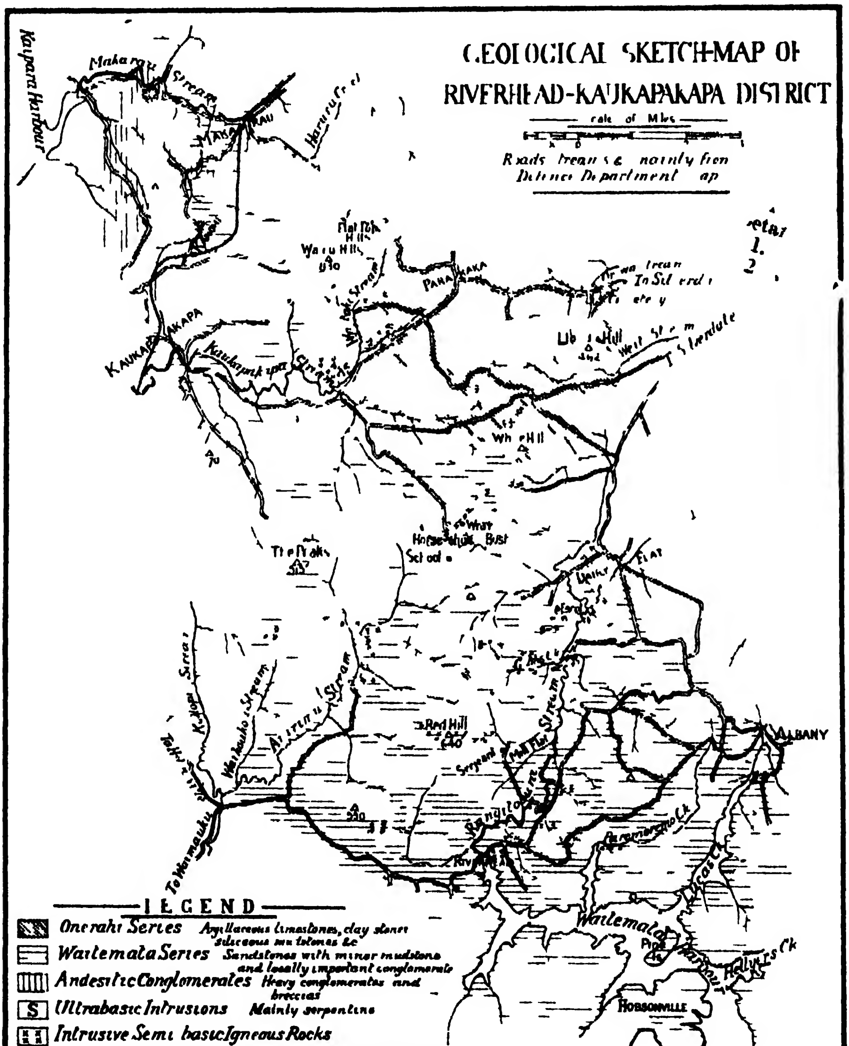
IN the present paper the intention is to describe the stratigraphy of a moderately extensive area of hilly country lying approximately between Riverhead, at the northernmost limit of navigation of Waitemata Harbour, and Kaukapakapa, a township approximately a dozen miles to the north-west. The area is mainly part of Auckland's "gum-lands," deforested open country covered here and there by small patches of forest, but usually clothed only by fern, scanty grasses, and scrub manuka. The country has moderate relief and a fairly intricate insequent drainage-pattern. Resistant rocks are relatively infrequent, so that both longitudinal and cross profiles of the stream-valleys in general are graded, and it is only where a relatively resistant rock is present, or where the streams rise steeply in their uppermost ungraded headwaters portions, that natural outcrops are obtainable. Many other similar areas of deforested country in North Auckland resemble the present one in this respect. Chemical weathering is particularly rapid in the warm, humid climate; there is a considerable depth of completely weathered surface-rock, and, as a consequence of constant burnings and the resulting imperfect cover of vegetation, the floors of the valleys of the smaller streams have become aggraded into swampy areas by soil-wash, aided effectively by various swamp-loving grasses. In such cases there is little chance of outcrops of the underlying rock.

For these reasons it has been found impossible to aid materially, by the results obtained in the study of the present area, in the solution of any of the yet unsolved problems of local geology.

It was found, however, that the district studied was most inaccurately mapped by earlier geologists. The writer is confident that the map he has prepared, though necessarily imperfect by reason of inaccuracy of detail in topography in the only maps available, and by reason of its small scale, will nevertheless help later investigators very materially. Whilst by no means every outcrop obtainable has been visited, yet careful search has been made in nearly all likely localities. Those familiar with the gum-lands of Auckland will recognize readily how impossible it is, without the expenditure of labour entirely disproportionate to the results likely to be obtained, to discover any but the more obvious outcrops.

EARLIER WORK

It is exceedingly doubtful if members of the early Geological Survey who mapped the area now described visited any but its marginal portions, for it is unlikely that certain phases of the geology could have escaped notice had the interior portions been visited The only work of any importance is that done in 1879 80 by Cox (1881), who travelled along



the main road northwards from Kaukapakapa, and reported on the geology of that part of the present area which lies between Kaukapakapa and the mouth of Makarau Stream. McKay later (1884, 1888) visited a number of intrusions of serpentine in the vicinity of Silverdale (Wade), and recorded this fact along with some extraordinary observations upon the rocks and their stratigraphic relationships. Some cursory remarks by Hector (1881)

in *Progress Reports* are practically the only other reference to the geology of the district that the writer has come across in the reports of the Geological Survey. He himself has recently described a variety of rocks from conglomerates outcropping near Albany and Riverhead (Bartrum, 1920).

SYNOPSIS OF STRATIGRAPHY.

The following stratigraphic units are recognized: (1) Onerahi series; (2) Waitemata series; (3) Andesitic conglomerate formation; (4) Pleistocene and Recent deposits.

The oldest rocks, which constitute the Onerahi series, include a prominent bed, generally spoken of as the "hydraulic limestone," which is a variably argillaceous, fine-grained, non-crystalline limestone. It most frequently represents an oceanic ooze rich in *Globigerina*, but is associated with fine shaly claystones and indurated siliceous mudstones, which seem in part to represent a local variation of the limestone and in part to be interbedded with it. The series-name selected is that introduced by Ferrar and Cropp (1921) for lithologically identical rocks conspicuous in the Whangarei district. There is no intrinsic evidence of age in the beds themselves, but their provisional generalized assignment to the Cretaceous period may be taken as approximately correct in the light of evidence obtainable in the Kaipara area farther north.

Above the Onerahi rocks -the facts indicate unconformably—there is an extensive series of argillaceous sandstones with minor interlaminated mudstone, which outcrop continuously southwards on the shores of Waitemata Harbour, but much less prominently in the northern part of the Kaukapakapa-Riverhead district. These beds belong to the Waitemata series, which appears from its fossil content near Auckland to be approximately Upper Miocene in age. In the area now mapped there are locally massive green sandstones and thick conglomerates of a most interesting nature forming part of the series. Northwards beyond the present area the massive sandstones are especially well developed.

The next formation in upward sequence consists of andesitic conglomerates and breccias, limited in extent to the north-west corner of the district now described, but traceable northwards, and also southwards where they build the Waitakere Hills, which border the west coast for many miles near Auckland. They appear to lie conformably upon sandstones of the Waitemata series in the few places where fairly clear sections are obtainable, and thus are regarded as approximately Upper Miocene in age. Pleistocene deposits next succeed the Waitemata beds and the andesitic conglomerates. They are represented by occasional terraces of alluvium, sometimes in flights of two or three, but seldom conspicuous. The majority of the stream-terraces do not show an aggradational phase in their history. Recent deposits are limited to linear swamps along the courses of slow-flowing streams. They are a constant feature of most of the valleys, but are by no means extensive. Occasional bog iron-ore deposits of small size, more extensive than elsewhere in small north-east-flowing tributaries of Gibbs Creek, a middle right branch of Rangitopuni Stream, are probably Recent in age.

The synopsis is completed by mention of intrusive igneous rocks. Of these there are two series: one comprises ultrabasic intrusions which now are represented by serpentinous rocks, and the other rocks of semibasic character. The first invade Onerahi beds, and have not yet been observed above that horizon; the others do not constitute a composite series, and differ in age.

DETAILED STRATIGRAPHY.

1. Onerahi Series.

Petrography and Distribution.

The facies of the rocks included in this series ranges from a *Globigerina* ooze containing over 84 per cent. of calcium carbonate to indurated siliceous mudstone in which there is no trace of organic remains, or to buff- and pink-coloured claystones. The component members of the series are therefore peculiarly difficult to diagnose stratigraphically with any certainty. Similar variations are usual in most of the more northerly occurrences of the rocks of the same series. The tests of *Globigerina* are numerous, but usually small, and are accompanied by few other genera of Foraminifera. A specimen collected from the lower course of Waitoki Creek above its confluence with Kaukapakapa Stream exhibits abundant and varied siliceous organisms in the calcareous matrix. Calcareous foraminifera are scarce, but broken spicules of sponges, small free-swimming diatoms, and radiolarians are all fairly plentiful. In addition there are abundant organisms resembling minute unbroken algal filaments, and others which the writer as yet has been unable to classify. Marshall (1916) has previously described similar siliceous marine organic remains from the "hydraulic limestone" near Batley, in the Kaipara district.

It has been found impossible to determine any regularity of structure in the Onerahi rocks. They are exposed comparatively rarely, and the claystones alone show definite bedding-planes. What evidence is available indicates that they are complexly disturbed, and are often crossed by zones of shattering.

In much of the area mapped as belonging to this series the boundaries are conjectural, on account of the paucity of outcrops. In addition there is doubt if the writer is correct in assigning to this, in preference to the Waitemata series, certain highly calcareous mudstones exhibiting no bedding, which are displayed adjacent to the road leading north-westwards from Kaukapakapa to Makarau Stream. They show notable difference in facies from the regularly bedded sandstones of the Waitemata series, which outcrop in juxtaposition southwards alongside the same road, and again northwards at Makarau Valley, where they are conspicuously developed. There are two other isolated outcrops of similar rock: one is about two and a half miles west of Makarau Railway-station, alongside the road following the lower Makarau Valley, whilst the other is visible about a quarter of a mile from Kanohi Railway-station, in a cutting of the road leading to Makarau.

Stratigraphically the inclusion of these areas of rock in the Onerahi series raises difficulties which are non-existent if they are placed with the Waitemata rocks. In a wide examination of undoubted Waitemata strata, however, the writer has not seen any which resemble these at all closely; he has therefore tentatively included them in the Onerahi series, though Cox (1881) does not differentiate such of them as he examined from the Waitemata beds.

The main occurrence of Onerahi beds is to be found south-eastwards of these outcrops of uncertain horizon. It begins immediately east of Wainui Hill, and extends south-eastwards through Parakakau Settlement beyond the limits of the area described in this paper. A few small inliers exist farther south.

Since outcrops are relatively scarce it is perhaps desirable to record where they can best be examined. Good exposures of argillaceous limestone exist abundantly in the upper and middle portions of the valley of Waitoki Stream eastwards of Waipui Hill. Again, in cuttings of the Parakakau–Silverdale Road a shaly red and grey claystone facies appears. It is steeply tilted, and strikes approximately north-east and south-west. Near White Hills, especially along the road leading south-east from the school towards Dairy Flat, there are excellent exposures of the white siliceous mudstone phase of the beds. North-westwards of the school, at the distance of about a mile along the track to Parakakau, a massive relatively resistant limestone is exposed, whilst about three miles westward of White Hills School a pure limestone is exposed in a quarry opened up for agricultural lime about a quarter of a mile north of the road to Kaukapakapa.

Onerahi beds probably occupy most of the district east of the Silverdale - Dairy Flat Road as far south as Dairy Flat, where limestone outcrops at the road near where it crosses the upper north-east branch of Rangitopuni Stream and also south-westwards in grass-lands on the right bank of this tributary.

It can next be found, continuing in a south-west direction, in Rangitopuni Stream below its confluence with the tributary just mentioned. Near Escot's house it is represented in the material dug from a well, though Waitemata sandstones shortly appear in a rill about 10 chains south of the house. South and south-westwards of Escot's there are two inliers of white indurated mudstones which must be referred to the Onerahi series. One is inconspicuously exposed in a trench cut many years ago for a mill-race on the right bank of Gibbs Creek about 300 yards above its confluence with Rangitopuni Stream. The other is represented by a number of outcrops in a belt over a quarter of a mile in width on the divide at the head of the same creek. Siliceous replacements of wood are common on the gum-track following this divide.

Finally, a small isolated area showing not only limestone but other phases is recognizable by fragments turned up in some post-holes, and by actual outcrops in the headwater basin of a small north-west-flowing stream a little south-west of Wray's house at Horseshoe Bush. Waitemata beds are extensively exposed in the upper portions of several small streams at no great distance eastwards, and can shortly be recognized northwards from the Onerahi limestone in imperfect outcrops furnished by slips adjacent to the road giving access to Wray's property.

Relations to other Series.

Actual contacts between the Onerahi strata and the overlying Waitemata rocks have not been discovered, though in several instances rocks of the two series have been found in close contiguity to what must be the actual surfaces of contact. In some instances the Waitemata beds apparently next above the Onerahi rocks are sandstones, in others they are conglomerates, a condition that might be expected with deltaic beds The conglomerates contain a large assortment of rocks both igneous and sedimentary, and it is not unusual to find pebbles of a *Globigerina* ooze microscopically indistinguishable from similar material composing Onerahi limestones, whilst fragments of other sediments comparable with other phases of the Onerahi beds often abound. Cox (1881) states that Hector

observed similar relations between the beds of the two series near Matakana North Head. Similarly, in a railway-cutting a short distance north of the cement-works at Portland, near Whangarei, pebbles of what appears certainly to be Onerahi limestone are present in a fine conglomerate of the succeeding series. These conditions are so widespread as to suggest unconformity rather than mere disconformity between the Waitemata and Onerahi series. This is in accord with conclusions reached by Ferrar (1922) as a result of recent field-work in the Whangarei and Bay of Islands Subdivision. Insufficient data are available to allow exact estimate of the nature of the surface of Onerahi rocks covered by the Waitemata series. In some localities it is obvious that it now is highly irregular, but it is impossible to be sure that such irregularity is not the result of diastrophic movements of more recent date than the period of deposition of the covering beds.

In this connection it is important to consider the relations of the calcareous mudstones north of Kaukapakapa (which have been mapped tentatively as Onerahi) to the andesitic conglomerate formation. At the roadside about a mile and a half north-north-west of Kaukapakapa the volcanic rocks overlie sandstones of the usual Waitemata facies, which have a slight westerly dip. In a very few yards the calcareous mudstones appear devoid of bedding-planes at a slightly higher level. Half a mile farther northwards these last beds are covered by volcanic material. Precisely similar relations obtain alongside the Lower Makarau Valley Road.

The evidence does not justify any hard-and-fast conclusions, since it is based on insecure lithological identification, but the deductions which seem to be necessary as a consequence of it are certainly instructive. If the white marls are correctly placed in the Onerahi series, either of the two following hypotheses will explain the facts:—

(*a.*) Assuming conformity between the volcanic and the Waitemata series, it is essential to postulate not only unconformity between the latter and the Onerahi rocks, but also a nicely adjusted emergence of small low islands of the earlier rocks through the Waitemata rocks prior to the covering of both series by volcanic fragmental beds.

(*b.*) If unconformity between the volcanic series and the underlying Waitemata beds be admitted, the facts are explicable whatever the relations between these latter and the Onerahi rocks, but more readily if unconformity exists, since otherwise diastrophic movements must necessarily have preceded the erosion that caused the uncovering of the two sedimentary series before the deposition of the volcanic strata.

The first hypothesis has little to recommend it, for so nice a balance of events as the conditions of field occurrence would require is unlikely to be attained.

In spite of the fact that the andesitic conglomerate formation is generally accepted as conformable to the Waitemata series, it seems advisable to keep in view the possibility of the truth of the second hypothesis, which is contrary to this belief.

2. Waitemata Series.

Petrography, Distribution, &c.

When traced north-west from Auckland along the shores of Waitemata Harbour, the beds of the Waitemata series preserve for many miles a marked regularity of type, and are predominantly somewhat feldspathic

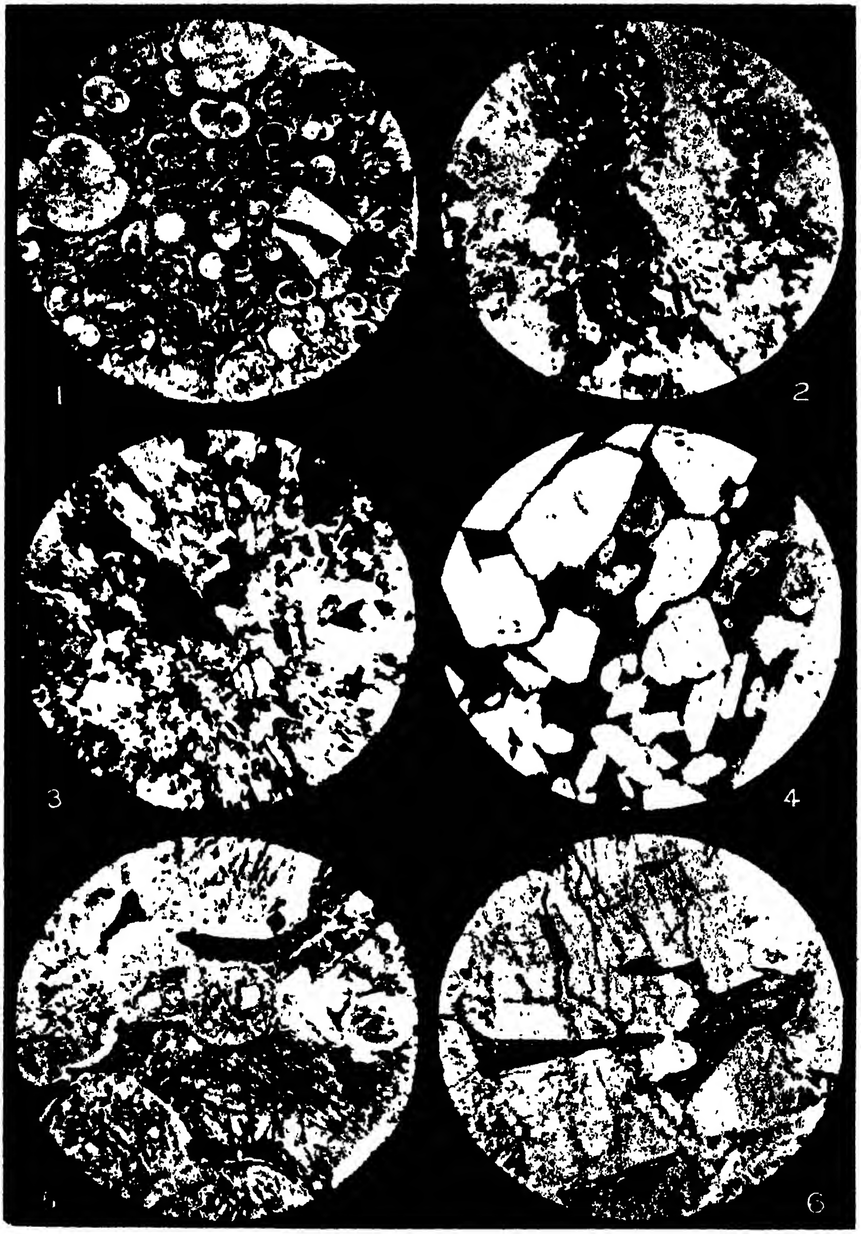


Fig. 1.—Crystalline limestone rich in foraminiferal, polyzoan, and echinodermal remains. Conglomerate in Waitemata beds, lower Rangitopuni Stream.

Fig. 2.—Gneissic hornblende diorite. Typical of many such diorites in the Waitemata conglomerates.

Fig. 3.—The same gneissic diorite viewed under crossed nicols.

Fig. 4.—Greenish-brown hornblende enclosing basic labradorite in an ophitic hornblende-gabbro from the Waitemata conglomerates.

Fig. 5.—Plagioclase and derived saussurite poecilitically enclosing partially serpentinized olivine in feldspathic peridotite from the "serpentine" quarry at Parakakau.

Fig. 6.—Anorthositic phase of the same "serpentine." Highly basic labradorite is enwrapped by accompanying diallage.

sandstones interbedded with frequent thin layers of mudstone. Carbonized remains of vegetation abound, but otherwise organic remains are scarce. The beds in this part of their extent are often complexly disturbed by small-scale folds and by faults which generally have unimportant throw. It is difficult amid this complexity to determine the major structure, but observations tend to show that the general strike is approximately N. 55° E., and that the beds rise successively in the series as followed north-west, at all events as far as Riverhead. At this latter place beds of conglomerate are intercalated in the sandstones and constitute a conspicuous feature of the geology for at least twelve miles northward.* Since his first description of their occurrence and petrographic interest, the writer has found them in numerous localities, and has recognized several fresh rock-varieties represented amongst the pebbles (Bartrum, 1920). His first impression was that they represented a definite horizon—at a higher level in the series, however, than the basal conglomerates near Papakura, and at Motu Tapu, Kawau Island, Cape Rodney, and other places where the Waitemata beds rest hard upon the mid-Mesozoic basement exposed in those localities. This view is almost certainly incorrect, for there are several bands of conglomerate exposed near Red Hill and elsewhere, which are separated by variable thicknesses of sandstone. Acute disturbance is the keynote of the structure, and there is the additional handicap of infrequent outcrops, so that accurate identification of horizon is difficult, if not impossible.

Petrographically the conglomerates are characterized by an abundance of dioritic pebbles along with various greywackes and argillites, andesites and other rocks. Their texture varies considerably. Not infrequently there is a gradual passage from sandstone through grit to fine conglomerate in which the pebbles average about ½ in. in diameter. Generally, however, there are numbers of coarse boulders, 3 in. or 4 in. in diameter, along with finer matrix, whilst exceptionally there are incorporated rock-masses 7 ft. and more in diameter. The dioritic boulders seldom exceed 1 ft. in diameter, whilst the especially large ones are invariably andesitic. In the majority of the exposures the freshness of all types of rock incorporated is very noticeable, but this statement is not applicable to those outcrops at the higher levels where conditions have favoured deep weathering.

Isolated large boulders of impure jasper, veined freely by small comby and drusy veins of quartz, are to be found here and there in areas of Waitemata beds. One noted in an easterly headwaters branch of the creek draining the north-east slope of Red Hill is unusually large and measures at least 25 ft. in diameter. None of these masses was discovered *in situ*, and the only explanation that the writer can offer of their occurrence is that they are local silicifications of the Waitemata beds. It is possible that siliceous springs furnished the silica required.

The distribution of the Waitemata beds is shown on the accompanying map, and need not be detailed in full. Their location has often been a matter involving an element of speculation because of the scarcity of outcrops. This is particularly the case for an area shown extending west from Lloyd's Hill, in the north-east of the map. Waitemata sandstones are indicated by soil, topography, and occasional outcrop; but much of the central portion of this area is clothed in dense forest, and was not examined.

* Cox (1881, p. 27) notes at Riverhead the discovery of "several specimens of volcanic rocks from boulders which appear to be included in the sandy marls."

The conglomerates are exposed near Riverhead Wharf in several places. Alongside the road to Albany, about a mile and a half north-eastwards of Riverhead, outcrops are visible in the beds of two small streams crossing the road, and immediately north of the more easterly of these last outcrops there is a thin band showing on the banks of Rangitopuni Stream at the uppermost limit of tide-waters. Farther north-east in the same stream, and in a cutting adjacent to the stream near where the road to Serjeant's crosses by bridge to the right bank, a heavy conglomerate at least 40 ft. in depth has prominent outcrop. Eastwards from Riverhead similar beds appear in Paremoremo Creek and at the roadside a little north-west of that stream. This band possibly is continuous in a north-easterly direction, reappearing as a strong stratum which outcrops near the lower wharf at Albany, on Lucas Creek, and from there for nearly two miles is traceable onwards by means of boulders shed by it.

North of Riverhead several bands outcrop in an area around Red Hill, and there is an exposure of similar conglomerate on one of the gum-tracks leading from the Riverhead–Helensville Road about two miles south-west from Red Hill. Some of these bands are only a few feet in depth, but others exceed 60 ft. In most of the branches of Gibbs Creek north-east of Red Hill the conglomerate is again found, but it is poorly developed beyond the areas already mentioned, until the Ararimu Stream is reached, where an extensive outcrop occurs. It can be traced northwards to The Peaks in divides west of Ararimu Stream, and was examined *in situ* in several small streams draining west to Kokopu Stream.

It is reported that there is an outcrop of conglomerate at Horseshoe Bush, but the writer did not locate it.

Continuing north, there is no sign of conglomerate until near the Kaukapakapa–Parakakau Road, where it outcrops in unmistakable fashion, probably covering nearly all the area between its mapped extent at Wainui Hill and its southern outlying outcrops adjacent to the Kaukapakapa–Parakakau Road. This is by far the most important development of the conglomerate, and its thickness, including minor beds of sandstone, cannot be much less than 700 ft.

About a quarter of a mile north of Makarau Railway-station a thin bed, less than 1 ft. in depth, with small dioritic and other pebbles, appears on the right bank of Makarau Stream in the massive sandstones typical of the Waitemata series as developed in that district. It serves as an indication that others of similar character are to be expected throughout such beds.

Whilst it is impossible to gain any accurate information on the subject, the facts indicate that the beds of conglomerate throughout the Kaukapakapa-Riverhead district are discontinuous and essentially lensoid in nature. Thin bands are probably of common occurrence, for characteristic boulders are to be found over wide areas other than these where definite outcrops are obtainable.

Relations to Associated Series.

The evidence of certain pebbles enclosed in conglomerates of the Waitemata series has already been shown to suggest widespread erosion of the Onerahi beds during Waitemata sedimentation. Onerahi strata do not outcrop in the mid-Auckland district south of the area which they have been shown to occupy at Dairy Flat, and the Waitemata beds rest, wherever the contacts are visible, upon a surface of Trias-Jura sediments. This

surface seems to have possessed very low relief at the time of ı if one may judge from the portions of it now bared for inspection in Papakura and at Waipu and other parts of North Auckland. It must be admitted that the fact of the Waitemata beds resting successively upon Trias-Jura and Onerahi ones can reasonably be explained by an hypothesis of progressive subsidence of a Trias-Jura basement that is undergoing accompanying tilting or warping below the seas in which later sedimentation is proceeding. Cotton (1916) invokes a comparable hypothesis in explanation of similar conditions in other parts of New Zealand. Nevertheless, this evidence, combined with that of the pebbles, furnishes a very strong case in favour of the existence of unconformity between the Waitemata and Onerahi series. There is further support of unconformity in the fact that Onerahi limestones appear immediately to underlie coarse Waitemata conglomerates in Waitoki Creek and a little east of the junction of Kaukapakapa–Parakakau and Kaukapakapa–Silverdale Roads. This abrupt change of facies from marine ooze to near-shore conglomerate implies very considerable marine regression, which must have introduced a greater or less degree of disconformity. This conception of the existence of unconformity is by no means a new one. Unconformity was described many years ago in places not far distant from the present district by both Cox (1881) and McKay (1884A, p. 104), but all fresh evidence is valuable, since some cases of such apparent unconformity are explicable by faulting.

The relations of the Waitemata to the overlying volcanic series have been discussed in some detail in earlier pages (see pp. 141, 143-44). It is sufficient to state that the evidence available in the area now described is inconclusive.

Origin and Petrography of the Waitemata Conglomerates.

The conglomerates generally comprise polished and well-rounded pebbles and boulders firmly cemented by finer matrix of more angular nature. The shape and well-polished nature of the boulders, and the occasional discovery with them of broken marine molluscan remains, indicate that the beds accumulated near the shore-line of the Waitemata seas, but no conclusion has been attained as to the exact location of the latter. Though no facts have been disclosed which can throw light upon the possibility of the material being a rewash of earlier conglomerates, its general freshness, and the rarity of similar conglomerates in older series, are against such a supposition.

In an earlier paper upon the conglomerate at Albany (Bartrum, 1920) the writer described many rocks of igneous origin. He has not made special effort to increase the list, for it is a matter of difficulty on account of the abundance of dioritic rocks which present considerable variety in hand-specimen, though microscopically they are closely allied. Though it has added very few fresh types, his additional work has demonstrated the essential uniformity of the dioritic batholites from which a great proportion of the pebbles of the conglomerates was derived. The general type has perhaps been an augite-diorite, though hornblende-diorites also are common. The augite of the augite-bearing types has been converted almost wholly to uralite, whilst more intense unilateral pressure here and there has developed granulation along with closely-spaced twinning-planes in the feldspars and even prominent gneissic and schistose structures.

Less-frequent acid phases of the magma have crystallized as granodiorites and quartz-monzonite, which seem to show more intense

The corphism than the diorites, for they are very commonly gneissic. basic facies are found as ophitic rocks which structurally and ralogically approach dolerites and epidiorites. The variety of feldspar that they contain is, however, seldom more calcic than andesine-labradorite, and is usually basic andesine, so that the writer's earlier designation of such rocks as dolerites is objectionable in spite of the dominance of ferro-magnesian mineral over plagioclase. It does not appear contrary to general usage to employ the term "epidiorite" for those types characterized by uralite, but the others are best called "diorite-porphyries." With them may also be included a few less basic rocks which have a structure approaching the trachytic. They are fairly coarse and non-porphyritic, and are built of dominant plagioclase in large irregularly disposed laths accompanied by uralite.

In addition to diorites, but probably derived from different intrusions, there are occasional gabbroid types represented amongst the pebbles. They include an anorthosite which already has been described (Bartrum, 1920). Other varieties are highly ophitic hornblende gabbro, with or without olivine. The hornblende has apparently been derived magmatically from hypersthene or augite, for these minerals survive as occasional remnant-grains amidst the hornblende.

The volcanic rocks of the conglomerate are predominantly andesites. They have not been closely studied, but are known to include hypersthene and hornblende types along with pyroxene-andesite containing both augite and hypersthene. Several trachytes were described amongst the Albany rocks, and locally are included abundantly in the conglomerate. Since describing them, however (Bartrum, 1920), the writer has had the opportunity of studying similar rocks from the Whangarei district, for which analyses are available. These showed unexpected acidity, and ranged from slightly calcic rhyolites to dacites. Trachyte-like rocks showing most minute resemblance to dacites of the Whangarei district have recently been found amongst the pebbles of the Waitemata conglomerates now described, and it seems probable that the types described as trachytes in the earlier paper are incorrectly classified. It is inadvisable, however, to attempt reclassification in the absence of exact knowledge of their chemical characters.

Rhyolitic material of rather felsitic nature is the main igneous constituent of some bands of finer conglomerate near Riverhead, but it is particularly scarce elsewhere, and only one specimen was collected from northern occurrences. It proved to be a type with phenocrysts of acid plagioclase and a little biotite surrounded by an abundance of turbid rather glassy base.

The source of the frequent masses of fresh andesite which are found in huge blocks as much as 8 ft. in diameter in several occurrences of the conglomerate has not yet been discovered. They are especially well displayed in a small tributary of Waitoki Stream, which drains the south flank of Wainui Hill. It is inconceivable that they have travelled far from their parent mass, yet no outcrops of similar andesites have been located, unless a greatly-weathered massive rock outcropping in a road-cutting a short distance west of the bridge over Rangitopuni Stream, on the road to Serjeant's, happens to be one. Flat-top Hill, immediately north of Wainui Hill, is an intrusive mass of semi-basic character, but its rock is quite unlike any of the andesites in the conglomerates.

Possible Unconformity in Tertiary Strata.

The writer found a fragment of crystalline limestone about 3 in. in diameter in the conglomerate which outcrops a short distance below the bridge over Rangitopuni Stream, on the road to Serjeant's. It contains *Globigerina*, *Rotalia*, and other foraminifers, along with crinoid stems, echinoid plates, polyzoans, and other calcareous organic remains. *Globigerina* is especially abundant. The limestone closely resembles many of the Tertiary limestones of the Auckland Province, of which the writer has examined a considerable number in microscopic section. Crystalline limestones certainly appear as thin bands closely associated with the hydraulic limestone near Pahi, in the Kaipara district, but, apart from this and what is perhaps a similar occurrence at Kawakawa, the crystalline limestones of that and the Whangarei district are usually considered to occupy the same horizon as the so-called Whangarei limestone, which Ferrar and Cropp (1921), as a result of their recent detailed survey, relegate to the Tertiary.

South of Auckland City the crystalline limestones have long been regarded as mid-Tertiary.

So little of a definite character is known of the geological history of the Auckland area during Tertiary times that it is as well to consider the possibility of the limestone pebble in the conglomerate having been derived from a Tertiary bed. This identification would suggest an unconformity in the Tertiary succession, which would have to be located somewhere above the limestone horizon. An alternative suggestion, however, is that the fragment of limestone was upthrown with other material from a subjacent limestone stratum by volcanic eruption, and later became incorporated in the conglomerate.

3. ANDESITIC CONGLOMERATE FORMATION.

The rocks of this formation are limited to the north-west portion of the Riverhead-Kaukapakapa district, but they can be traced almost continuously south to the Waitakere Hills, west of Auckland, which are a resistant range composed on its eastern flank mainly of tuffs and on its western of andesitic fragmental rocks of coarse and varied kind. Beyond the Makarau Stream the same beds have an important northerly extension. The relations of these volcanic beds to the Waitemata series have been sufficiently discussed on pages 141 and 145. Where undoubted Waitemata beds and the volcanic rocks were seen in contact there was no indication of unconformity.

The petrographic nature of the constituent material of the conglomerates and breccias was not examined microscopically. In the Waitakere Hills mass pyroxene-andesites are exceedingly common.

4. PLEISTOCENE AND RECENT DEPOSITS.

A synopsis of the nature and occurrence of these beds sufficient for the purpose of this paper has been given on page 141. The origin of the small deposits of iron-ore, which are represented by irregularly nodular masses of impure limonite 1 ft. and more in diameter, which are scattered plentifully upon the surface in a few localities, is debatable. Such deposits are frequent throughout northern Auckland, and have varied relations to topography, for they occur upon tops of plateaux and on benches high on the walls of valleys as well as upon their floors. The limonite has undoubtedly originated

in some instances, though not in others, as a deposit in former swamps. It was noted that the nodular masses often lie upon the exposed surface of a relatively impervious stratum near its contact with more pervious overlying material, and it is probable that seepage of water rich in iron salts along such junctions has given rise to their formation.

Igneous Rocks.

It is unnecessary to add further description to such mention as already has been made of the igneous rocks represented in the Waitemata conglomerates, and this section will therefore be reserved for a brief statement of such other igneous rocks as have been found. The majority occur as intrusions of ultrabasic character penetrating Onerahi rocks, and are described in the next paragraph. In addition there are several other less important occurrences which will be described.

Ultrabasic Intrusives.

This series of rocks, which can broadly be called "serpentines," abundantly intrude Onerahi limestones and claystones.* The rocks themselves are not sufficiently resistant to form outcrops in any way conspicuous in their relation to topography, and they are therefore discoverable only by patient search.

The following are the main occurrences:—

(*a.*) On the east and north-east slopes of Flat-top Hill.

(*b.*) Alongside the Parakakau Silverdale Road, a short distance from its junction with the Parakakau-Kaukapakapa Road, there is a large interesting mass which has been extensively quarried. A small intrusion of serpentine can also be seen on the same road, near where it gains the summit of the divide between the Orewa and Kaukapakapa drainage basins.

(*c.*) Farther along the Parakakau–Silverdale Road serpentine outcrops near the cemetery shown on the map. The main body has been quarried west of the short branch road giving access to the cemetery, but it can be traced in much-weathered state farther east.

(*d.*) East of White Hills School there is an outcrop adjacent to the Silverdale Road on Mr. Davidson's farm, but it was not examined by the writer.

(*e.*) Near White Hills School there are several exposures representing apparently the one intrusion. The rock is exposed in the road-cutting near the school, and in several places north-westwards. At one of these latter outcrops a quarry has been opened up.

(*f.*) About a mile west of White Hills School.

(*g.*) On the valley-slopes of a small stream separating Wray's house from the school at Horseshoe Bush.

Most of the intrusions recorded are represented on the accompanying map in their approximate positions.

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* Since this was written a short report by Mr. H. T. Ferrar upon the Silverdale district (*17th Ann. Rep. N.Z. Geol. Surv.* (n.s.), 1923, p. 8) has appeared, in which it is stated that the serpentines underlie the Onerahi beds. The evidence submitted is unconvincing, and the supposition raises many more difficulties than it attempts to remove.

The list given cannot be regarded as by any means exhaustive: many unobtrusive occurrences have doubtless been passed by unobserved.

In reality the "serpentines" differ considerably in their true character one from another. The majority vary between wholly serpentinized dunite with subsidiary bastite, and rocks in which the bastite has increased so considerably in proportion to serpentine that the name "harzburgite" is merited. Usually the crystallization is not particularly coarse, but in parts of the intrusion east of Wainui Hill the bastite forms crystals as much as 1 in. in largest dimension. The "serpentine" near the cemetery adjacent to the Parakakau–Silverdale Road, though mainly derived from original dunite, has portions which have a very different character. One such is mainly chlorite along with epidote and sphene.

The Parakakau quarry has opened up a rock possessing very great interest. Not all phases are now obtainable actually *in situ*, though they may be collected from quarried rubble, so that the field relationships between the phases are not observable. Much of the material is crushed and slickensided, and is penetrated by numerous narrow veins of chrysotile, but there is a quantity of less-completely altered rock which varies from typical troctolite to a greenish-black rock which shows successive gradations towards dunite-serpentine. The dark rock is built of chondri of partially serpentinized olivine enwrapped poecilitically by a moderately refractive, colourless, altered mass, which is only faintly birefracting, and which is probably referable to saussurite, since there are occasional remnants of basic plagioclase associated with it. The troctolite is evidently a relatively acidic variation of the feldspathic peridotite, for the proportions of the saussurite and plagioclase to original olivine vary greatly in the sections examined.

In dump-heaps of the same quarry there are frequent fairly coarse fragments of a white pyroxenite which consists in the main of two minerals; the more important is a colourless monoclinic pyroxene, which from casual inspection seems to be diopside, and with it is a fairly large amount of diallage. The full study of this and several others of the rocks has not yet been attempted.

Quartz-porphyrite of Flat-top Hill.

This rock forms a neck consisting partly of lava, partly of fine well-consolidated tufaceous breccia, which penetrates Onerahi beds and forms the elevation of Flat-top Hill. The eruption seems to have preceded the deposition of the Waitemata series, for the porphyrite shows evidence of pressure in bent laths of plagioclase and other points of entire dissimilarity from the post-Waitemata eruptions of the Auckland Province. Petrographically the rock is an open-grained non-porphyritic type built of a plexus of laths of plagioclase (andesine) which enwrap subordinate pale-green, partially chloritized augite, and a little magnetite. There are numerous small rounded areas of quartz built in an irregularly intergrown and radiate fashion. Often they enwrap or enclose the plagioclase. Thus, unless they replace some earlier mineral, of which action there is no evidence, they have crystallized before complete solidification of the porphyrite. As there is every reason to believe that the quartz is a pneumatolytic precipitate from the original magma, the rock has been classed as a quartz-porphyrite.

Doleritic Rocks.

The rocks described under this heading are believed to represent masses intrusive into the Onerahi beds. Certain of them have been found only as boulders, but there may be actual outcrop in the headwaters of Orewa Stream. All are to be found within a short distance of the cemetery adjacent to Parakakau Silverdale Road.

The dolerite from Orewa Stream is discoverable only with difficulty. It occurs as small fragments in the low right bank of the stream, about a quarter of a mile west of the cemetery. One large block partially bared in a small excavation appears to represent the actual outcrop of a dyke. If so, the dyke is likely to be a narrow one, for the rock is much more resistant than the surrounding beds, and if in moderate quantity would certainly give topographic indications, which are now lacking, of its presence.

Petrographically the dolerite is a relatively coarse, holocrystalline, poorly ophitic rock, made up of about 75 per cent. plagioclase along with almost colourless partially-uralitized augite, a little ilmenite, and rare crystals of green hornblende. Frequent narrow, white, secondary veinlets have not been closely studied, but appear to consist of opal with a little radiating zeolite.

A little east of the cemetery there are numbers of boulders lying on the surface which have very uniform macroscopic appearance, but which when sectioned show some variety, though perhaps not greater than is to be expected in specimens from different parts of the same intrusion. One of the coarser specimens proves to be a basic dolerite, or an epidiorite, with only about 25 per cent. of plagioclase (labradorite) in slender laths. The rest is pyroxene, or uralite derived from that mineral, with a little magnetite and occasional picotite. Some small crystals of unaltered though marginally resorbed hypersthene are present, but the main mass of the pyroxene has been pale augite now almost completely converted to uralite except in a few parts of the section. A fine-grained, non-porphyritic epidiorite shows perfect fine-scale ophitic structure, with some fluxional arrangement of the plagioclase (basic labradorite), which here forms nearly three-quarters of the rock. The pyroxene is completely uralitized.

Mr. H. T. Ferrar, of the Geological Survey, kindly supplied the first specimen that the writer obtained of these epidioritic boulders. In a report furnished to Mr. Ferrar it was suggested that the boulders had been shed from conglomerates in the pre-existing Waitemata cover. Later collecting, however, has established a comparative uniformity of type which contrasts with the diversity usual in the conglomerates, and there can be little doubt that the rocks are actually intrusives which penetrate the Onerahi claystones of the vicinity.

Basalt near Wray's House, Horseshoe Bush.

About 150 yards north-east of Wray's house at Horseshoe Bush the writer found some fragments of basalt in a small gulch on the south side of the track leading to Dairy Flat. The rock differs considerably from the Quaternary basalts of Auckland, Lower Waikato, and North Auckland, for it contains much less plagioclase (not more than 25 per cent.), and exhibits prominent zonal structure in the augite which is abundantly present. Olivine is fresh, coarse, abundant, and in euhedral crystals. The augite is in numerous sharply idiomorphic zoned crystals, and with it are associated very plentiful small flakes of deep-brown biotite. There is a moderate quantity of magnetite, whilst apatite is in very long sharp needles. The matrix is constituted by weathered laths of plagioclase.

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Descriptions of Two New Species of Gastropod Shells.

BY ALBERT E. BROOKES.

[*Read before the Auckland Institute, 14th December, 1922; received by Editor, 28th December, 1922; issued separately, 26th May, 1924.*]

Plate 7.

TATEA, Ten.-Woods, 1879, *Proc. Roy. Soc. Tasm.*, p. 72.

Tatea hedleyi n. sp. (Plate 7, figs. 1–3.)

Shell small, elongate, conical, with rounded nucleus, and without any perceptible sculpture except a few faint growth-lines. Colour pale buff, with narrow ochraceous bands below suture. Whorls 5½, convex, with rather deeply impressed sutures. Body-whorl more than half the height of all preceding ones taken together. Protoconch depressed, consisting of one turn. Spire about 1¼ the height of aperture. Aperture ovate, angled above, base rounded, descending. Peristome discontinuous, with margins united by a thin parietal callus. Basal lip thickened, outer lip thin. Columella short and rounded. Umbilicus consisting of a narrow chink. Operculum thin, horny, transparent, paucispiral, with nucleus subcentral, slightly raised and nearer base, upon which are several broad shallow grooves.

Diameter, 1·7 mm.; height, 2·5 mm.

Animal unknown.

Holotype and paratypes in my collection, and paratypes also in the collection of the Australian Museum, Sydney.

Habitat.—Rangitoto Island, Hauraki Gulf, Auckland.

Situation.—Under decaying *Zostera*, near high-water mark.

Numerous specimens were obtained. It adds a genus and a species to our fauna.

Distribution.—Tasmania (genotype); Australia; Macquarie Island.

Remarks. *Tatea huonensis* Ten.-Woods was stated by its author to have an operculum "calcareous, with a vertical submarginal claw" (1). This very serious and misleading error was perpetuated by Tryon (2), but was somewhat rectified by Mr. E. A. Smith, who states, "As far as I can discover, judging from an external view, it appears to be thin, horny, paucispiral, with the nucleus subcentral, but rather towards the base" (3). After having examined the operculum of a number of specimens of *T. hedleyi* I can fully confirm the views of Mr. Smith. This interesting species is named in honour of my esteemed friend Mr. C. Hedley, of the Australian Museum, Sydney, who discovered it while on a visit to New Zealand in 1917-18, and to whom I am greatly indebted for kindly assistance rendered at various times.

This species is not so elongate as is usual with other members of the genus.

MARGINELLA, Lamarck, 1799, *Mem. Soc. N. H. Paris*, p. 70.

Marginella cairoma n. sp. (Plate 7, figs. 4-5.)

Shell small, elongate, transparent and shining. Spire bluntly rounded. Sculpture consisting of fine growth-lines crossed by very fine spiral threads, giving the surface, under the mscroscope, a very fine decussated appearance. Without the aid of a good lens the shell appears quite smooth and polished. Colour pale cream-buff (Ridgway's colour standards) with a whitish narrow band above suture. On upper whorls there are ochraceous-orange bands, and two on body-whorl extending over outer lip into aperture. Outer lip and base whitish. Spire conical, not much produced, with bluntly-rounded apex, about half the height of aperture. Protoconch of about 1½ turns, nucleus flattened. Whorls 4, very slightly convex. Last whorl long and narrow, widest at top and gradually narrowing towards base. Suture superficial and distinct. Aperture slightly oblique, narrow, channelled above, rounded below. Outer lip nearly straight, rounded, and thickened, with an indistinct varix, retrocurrent towards suture, smooth inside. Columella slightly oblique, with four subequidistant plaits, the two lower ones oblique and thicker than the upper ones. Top plait short and nearly transverse, the lower extending to basal margin. Inner lip thin and transparent.

Diameter, 1·8 mm.; height, 4·2 mm.

Animal unknown.

Holotype and paratypes in my collection, and paratypes also in the collection of the Australian Museum, Sydney.

Habitat.—Russell, Bay of Islands (A. E. B.); near Taipa, Doubtless Bay (type, A. E. B.).

Situation.—Under loose boulders embedded in sand, near low-water mark.

Remarks.—Three specimens were collected at Russell, and about twenty at Doubtless Bay, and all were alive.

This species is allied to *M. allporti* Ten.-Woods, but the absence of tubercules in the outer lip, and its constant narrow form, separate it from that species.

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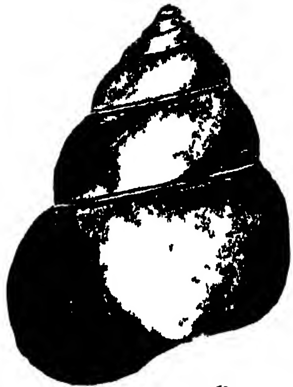
1



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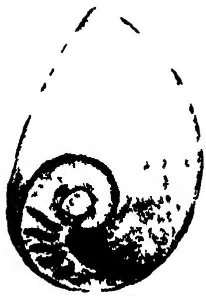

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Figs. 1, 2.—*Tatea hedleyi* n. sp.
Fig. 3. *Tatea hedleyi* n. sp.: operculum.
Figs. 4, 5.—*Marginella cairoma* n. sp.

The Tertiary Rocks of the Wanganui – South Taranaki Coast.

By P. MARSHALL and R. MURDOCH.

[*Read before the Wanganui Philosophical Society, 11th December, 1922; received by Editor, 31st December, 1922; issued separately, 26th May, 1924.*]

IN various publications during the last few years we have endeavoured to solve the faunal and stratigraphical relations between the various members of the series of rocks exposed on the coast-line between Wanganui and Hawera. We have stated that as far as the mouth of the Tangahoe Stream the dip of the rocks is such that older and older strata are gradually exposed as one goes north and west. The strike of the strata, however, bends so far to the west that north of the Tangahoe the strata exposed on the coast-line become gradually younger, and repeat the series exposed between Patea and that place, though they are somewhat more fossiliferous.

At the mouth of the Waingongoro Stream, some four miles north-west of Hawera, the old post-Pliocene surface of erosion approaches closely to the present sea-level, and almost the whole height of the cliffs consists of detritus from Mount Egmont. At the base of this material there is in places a well-preserved shell-bed, the presence of which shows clearly that at the time the volcanic activity of Mount Egmont commenced the post-Pliocene surface of erosion was the floor of a shallow marine area. The absence of shell-bearing horizons at higher levels in the volcanic material shows either that elevation of the old sea-floor took place when the volcanic activity began, or that the sea was so shallow that the volcanic matter which was deposited soon accumulated to such a thickness as to build up a land surface. At the mouth of the Waingongoro Stream it is clear that the old fossiliferous surface had been elevated to a higher level than the present before the volcanic activity commenced. In this locality the present stream enters the sea through a gorge cut in the debris of volcanic material derived by erosion from the slopes of Mount Egmont, the sides of the gorge being about 100 ft. high. Some 400 yards along the coast to the south-east of the gorge the volcanic material of the lower part of the cliff abuts against the grey claystone of the district (called everywhere "papa"). The abruptness of the junction at once suggests a fault, but closer inspection shows that the papa wall is an old gorge-cliff, and evidently formed the south-east side of the post-Miocene Waingongoro Valley. About 300 yards north of the Waingongoro Stream there is a similar abrupt appearance of papa, which marks the cliff boundary of the old valley in this direction. It is thus evident that previous to the activity of Mount Egmont the Waingongoro Stream had eroded a valley which was nearly half a mile wide, and there is at present no means of telling how far below the present sea-level the old floor of the valley lay. The depression of this old floor took place, and the land-level sank until the tops of the cliffs that then bounded the valley were submerged, when a beach-deposit with Recent marine shells was formed; volcanic detritus was, however, subsequently carried to the sea in such quantity that the shell-deposit ceased.

As has been mentioned, at the Waingongoro the trend of the coast intersects the strike at such an angle that successively younger beds are encountered as one goes north and west. At the same time the thickness of old claystone showing in the cliff is gradually narrowing, and at the mouth of the Kapuni Stream it has sloped below the present sea-level. Our hope of finding a succession of Tertiary beds which might connect the Whakino-Waihi horizon with that of older localities was thus frustrated on the coast-line to the south of New Plymouth. The country and coast-line north of New Plymouth to the mouth of the Urenui Stream is fully described in *Bulletin No. 14* of the Geological Survey. That detailed survey did not offer us much encouragement, for only thirty-four species of Mollusca are mentioned as occurring in the Onairo series, the youngest Tertiary series mentioned, and equivalent to the Upper Miocene. Apparently this list includes fossils from all outcrops in the district discovered by all observers up to the year 1912. No particular locality or station is mentioned by the writer of the bulletin as one in which a typical collection could be made.

During our brief visit to the district we found a considerable number of fossils near Uriti, where there is an old disused metal-pit of shell-rock, known as Wray's quarry, situate on the road up the stream about half a mile from the township. Many of the fossils are poorly preserved, and species determination is therefore unrecorded.

The following is a list of species, those extinct being marked with an asterisk:—

**Ancilla pseudo-australis* Tate
Anomia sp.
**Antigona* sp.
Calyptraea novae-zelandiae Less.
**Cardium spatiosum* Hutt.
**Cerithidea* sp.
**Cerithiopsis* sp.
**Cominella* sp.
**Crepidula gregaria* Sow.
**Dentalium solidum* Hutt.
**Diplodonta ampla* (Hutt.)
Dosinia subrosea (Gray)
**Galeodea senex* (Hutt.)
**Glycymeris globosa* (Hutt.)
**Lima paleata* Hutt.
**Lima* sp.
**Limopsis zitteli* Iher.
**Macrocallista* sp.
Mactra scalpellum Reeve
Malletia australis (Q. & G.)
**Natica gibbosa* Hutt.
Ostrea sp.
**Paphia curta* (Hutt.)
**Pecten* aff. *sectus* Hutt.
Psammobia aff. *lineolata* Gray
**Sinum* sp.
**Struthiolaria spinosa* Hect.
Turritella symmetrica Hutt.
Venericardia difficilis (Desh.)
**Verconella conoidea* Zitt.
**Verconella nodosa* var.
**Zymene* aff. *lepidus* Sut.

Of this total of thirty-two species, nine are Recent, the percentage of extinct species being 71·9. *Lima paleata* is not recorded above the Oamaru limestone. *Galeodea senex* reaches its upper limits in the Awamoan beds. *Struthiolaria spinosa* has not a widely recorded occurrence, but is found in the Upper Miocene of the Trelissick Basin. The other extinct species, though they occur at lower horizons in the Miocene, extend also to higher ones. The species mentioned seem to imply an horizon not lower than that of Target Gully beds, and this is in accord with the suggestion due to the percentage of Recent species.

Some Tertiary Mollusca, with Descriptions of New Species.

By R. MURDOCH.

[*Read before the Wanganui Philosophical Society, 11th December, 1922; received by Editor, 31st December, 1922; issued separately, 26th May, 1924.*]

Plates 8–10.

PINNA.

IN his *Catalogue of the Tertiary Mollusca and Echinodermata of New Zealand*, 1873, page 26, Hutton described three species of *Pinna*—viz., *lata*, *plicata*, and *distans*. Suter, in the "Revision of the Tertiary Mollusca of New Zealand," *Geological Survey Bulletin No. 3*, part 2, page 53, points out that *plicata* is a fan-shaped fucoid, and must be removed from the list of fossil Mollusca. Of the other two species, the type of *lata* appears to have been lost. Hutton's description is exceedingly brief, and there has always been some doubt as to the identity of the species; but fortunately Buchanan left a drawing of the type specimen (here reproduced), which is the clue to the species. The species *distans*, the type of which is preserved in the Geological Survey collections, and is also figured by Buchanan, proves to be a large fragment of a cast, in fine greyish-brown rather soft sandstone, the anterior and posterior ends broken off. No part of the shell is preserved, and the sculpture is therefore the radiating furrows on the interior surface of the valves. For the loan of the drawings prepared by the late Mr. Buchanan I am indebted to Mr. P. G. Morgan, Director of the Geological Survey. I am also indebted to Mr. H. J. Finlay, of Dunedin, for the loan of specimens.

Pinna lata Hutton. (Plate 8, figs. 1, 2, and Plate 9, fig. 2.)

Original Description.—Broadly triangular, with concentric striae, anterior end rather excavated. Height, 8; length, 7·25; angle of apex, 60°. Locality, Cobden.

In view of the specimens before me, there appears to be no doubt that the above description refers to a large fragment of the wide posterior end. A close scrutiny of Buchanan's figure shows a very imperfect shell with some radiate riblets on the narrow end, of which Hutton makes no mention. A specimen received from Finlay, doubtfully from Caversham sandstone, closely agrees with Buchanan's figure, and the specimen can be perfectly matched with the posterior area of a well-preserved specimen from Awamoa. The latter in form and sculpture is widely different from Hutton's description, and it is necessary to redescribe the species. I offer the following:—

Shell large, narrowly triangular, angle of apex 33°, beak pointed, dorsal margin straight, posterior end oblique produced below, basal margin a little convex posteriorly. Clothed with a thick dark periostracum, nacreous beneath. Sculpture: Apical half and from median area dorsally with fine radiating riblets, crossed by smaller threadlets, both narrower than interspaces, on basal area irregular growth-lines and undulations rather strongly curved to median area, where they are wave-like and gradually widening posteriorly, posterio-dorsal area with irregular growth-lines. The fine

transverse threadlets of dorsal area absent on the nacreous shell, the longitudinals less numerous, while basal sculpture is same as on periostracum.

Length, 280 mm.; width, 140 mm.; diameter, 40 mm.

Locality, fine sandy clay in bed of Awamoa Stream, about half a mile inland from the Coast Road, Oamaru. Collected by Dr. Marshall.

Specimen to be presented to the Wanganui Museum.

In the Geological Survey collections is an imperfect specimen, locality not recorded. In Mr. Finlay's collection is a large fragment from Waikouaiti sandstone, a small cast from Caversham sandstone, and the large fragment previously mentioned and doubtfully referred to the Caversham sandstone. These certainly represent the Awamoan horizon. Mr. Finlay writes that from the matrix he obtained *Alectrion socialis*, *Bulinella soror*, *Dentalium mantelli*, and *Malletia australis*.

Pinna distans Hutton. (Plate 9, fig. 3.)

Original Description.—Large, with distant plications, the ridges being much narrower than the furrows. Height, 9; length, 4·5; angle of apex, 40°. Locality, Caversham.

The type, as previously mentioned, is a cast only, and agrees perfectly with Buchanan's figure, which is here reproduced. There are about eleven prominent distant ridges on the dorsal area, and on the basal area a number of irregular upward-curving folds less strong than the radiations above. A fragment of a cast from Milburn limestone in Mr. Finlay's collection perfectly agrees in sculpture with the type. On present material little more can be added. The species appears to be closely allied to *lata*, the greater prominence of the radiations being the distinguishing feature. In the Suter collection are two small fragments from Waihora River, two miles from Te Karaka, Poverty Bay. They are casts of the apex, and are labelled "*distans*," but the radiating sculpture appears to me identical with the Awamoan specimen, which I refer to *lata*.

Chalamys.

Chlamys oamarutica n. sp. (Plate 9, fig. 4.)

Shell (left valve) small, thin, nearly equivalve, very little inflated, ears unequal triangular; posterior small and very oblique; dorsal margins of disc descending slightly concave, anterior, posterior, and basal margins rounded. Sculpture consists of thirteen or fourteen small radiate ribs, sparsely gemmate and much narrower than interspaces, in the latter one, two, or three smaller riblets on basal half of disc, in addition the whole shell is adorned with an exceedingly delicate lacework-like sculpture. Anterior ear with about six small riblets, posterior ear with three somewhat scaly riblets. Interior hinge-line somewhat oblique, narrowly grooved within margin, resilifer-pit small and slightly oblique, adductor-scars indistinct, radiate grooves correspond with external sculpture and lightly crenulate the margin.

Dimensions: Dorso-ventral, 26 mm.; ant.-post., 24 mm.

Type to be presented to the Wanganui Museum.

Locality, Target Gully shell-bed, Oamaru.

It is with some hesitation that I describe this species from a single valve. Its sculpture, however, appears to distinguish it well from other of our Tertiary and Recent forms.

Chlamys grangei n. sp. (Plate 9, fig. 1.)

Shell (left valve) small, ovate, height and length about equal, somewhat inflated, almost equilateral, beak rather abruptly incurved, dorsal margins declining slightly convex, ends imperfect, basal margin rounded. Sculpture consists of about twenty narrow radiating riblets more slender on sub-marginal slopes, midrib on disc somewhat stouter and more prominent, grooves rather more than twice width of riblets with an occasional small radial not continuing to apex, in addition transverse sculpture of fine threadlets better marked in grooves. Ears: Posterior narrow, dorsal margin ridged, and with two or three indistinct threadlets; anterior imperfect, it has three or more riblets and transverse threadlets. Interior filled with matrix.

Dimensions: Dorso-ventral, 20 mm.; ant.-post., 20 mm.

Type to be presented to the Wanganui Museum.

Locality, gritty shell-limestone bed, Brighton. Collected by Dr. Marshall.

It appears not unlikely that this species is the same as recorded by Grange (*Trans. N.Z. Inst.*, vol. 53, p. 163, 1921), and with it a species of belemnite. The little that is known of the fauna of this horizon suggests that it is Cretaceous.

VERCONELLA.

Verconella marshalli n. sp. (Plate 10, figs. 1-3.)

Shell fusiform, spire short, whorls convex, body inflated, canal produced. Sculpture consisting of fine spiral cords slightly variable, and with one, at times two, small threads in grooves; axials feeble or growth-striae only on body, higher whorls of spire with well-developed rounded costae. Whorls about eight in all, protoconch small, of about two and a half smooth rounded coils. Sutures not deep, usually rather more impressed on higher whorls. Aperture oval, produced into fairly long open canal curved somewhat backward and to left; outer lip effuse and lirate within, margin more or less excavate above and narrowly channelled at suture; columella concave, wall with a thin callus not concealing spiral sculpture, or with series of denticles only near outer margin, occasionally a small callus nodule near suture.

Length, 74 mm.; width, 34 mm. (A small specimen, length 49 mm., width 21 mm.)

Locality, Castlecliff blue sandy clays; also in the Kai Iwi, Okehu, and Nukumaru beds.

Type in the Wanganui Museum.

This species is not uncommon in the Castlecliff beds. It appears to be nearest to *V. mandarina* Duclos, from which it may readily be distinguished by the small spire and inflated body-whorls; small or juvenile specimens with less inflated body may be distinguished by the finer sculpture and less impressed sutures; it has been confused with *mandarina* and with *valedicta.*

It also occurs Recent, a few specimens having been obtained by dredging in Hauraki Gulf (16 fathoms) by Mr. La Roche, of Auckland. In the Dominion Museum, under the name of *Siphonalia valedicta* Watson, are three specimens, exact locality not recorded. In colour the Recent specimens are a light reddish-brown, and within the aperture in young individuals pale pink. The operculum is oval, rather pointed at the ends,

and the nucleus apical. A fossil specimen is chosen for the type on account of the large series available.

I name this handsome species after my friend Dr. P. Marshall.

Erato.

Erato neozelanica Sut. (Plate 10, fig. 4.)

E. neozelanica Sut., *N.Z. Geol. Surv. Pal. Bull. No. 5*, pt. 1, p. 12, pl. iii, figs. 6, 7.

The holotype was collected by Marshall in the Target Gully shell-bed, Oamaru, and presented to the Otago University Museum. Another specimen is now recorded from the sandy clays in the bed of the Awamoa Stream, near Oamaru. It is rather smaller than the type: length, 11 mm.; width, 7 mm. It has also been found to occur in the railway ballast-pit near to the Okehu Station (a single specimen length, 12 mm.; width, 7 mm.). This horizon appears to be a little above the *Rotella* bed of Park as exposed in the coastal cliff at the boat-sheds, Nukumaru. The species would appear to be rare, but has a fairly wide distribution.

In the Suter collection are two small specimens labelled "*E. neozelanica*, 'paratype,' Target Gully shell-bed, Oamaru." They are pygmies compared with the typical form. One specimen is certainly fully adult. They appear to me to be quite distinct from *neozelanica*, and I treat them as an undescribed species.

Erato senectus n. sp. (Plate 10, figs. 5, 6.)

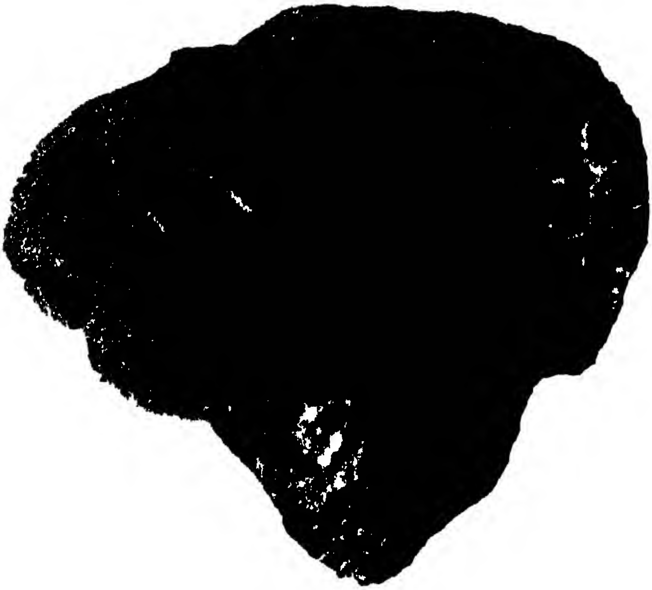
Shell small, pyriform, without sculpture, spire about three whorls, short with blunt apex, coated with enamel, sutures lightly indicated, last whorl large, almost uniformly curved to the short beak, outer lip broad and rounded, exteriorly forming a ridge, on anterior area a few teeth-plications passing across it, its lower surface crossed by ten to a dozen stout teeth. Aperture narrow, oblique, almost uniform in width; columella a little excavated anteriorly, with three or four small plications, and a few or numerous denticles above.

Length, 4·5 mm.; width, 3·25 mm.

Locality, Target Gully shell-bed, Oamaru. Collected by Dr. Marshall.

Type in the Wanganui Museum, Suter collection.

Differs from *N. neozelanica* Sut. in its much smaller size, less narrowly produced anteriorly, and the outer lip heavier and more strongly plicated.



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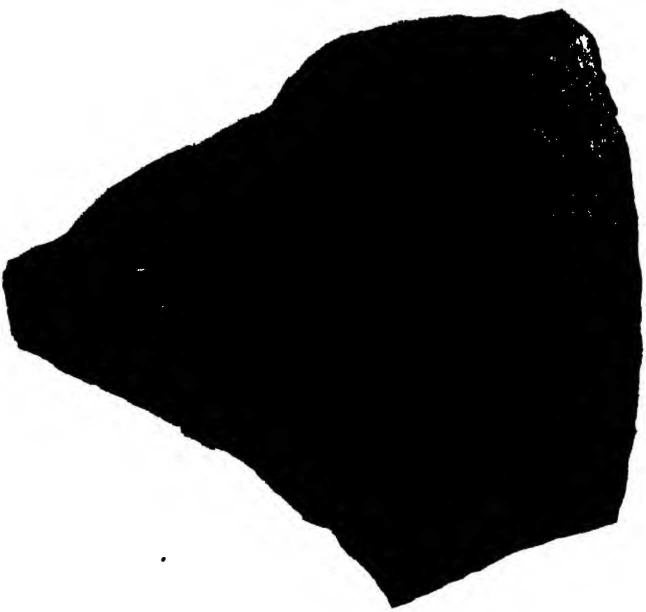


FIG. 1.—*Pinna lata* Hutt. From Buchanan's figure.
FIG. 2.—*Pinna lata* Hutt. Specimen in Finlay's collection.

Fig. 1. *Chlamys orangei* n. sp.
Fig. 2. *Pinna lata* Hutt. From Awamoa.
Fig. 3. *Pinna distans* Hutt. From Buchanan's figure.
Fig. 4. *Chlamys oamarutica* n. sp.

Fig. 1.—*Verconella marshalli* n. sp.
Figs. 2, 3. *Verconella marshalli* (juv.).
Fig. 4.—*Erato neozelanica* Sut. From Awamoa.
Figs. 5, 6.—*Erato senectus* n. sp.

The Struthiolariidae.

By J. MARWICK, M.A., N.Z. Geological Survey.

[*Read, by permission of the Director of the N.Z. Geological Survey, before the Wellington Philosophical Society, 9th August, 1922; received by Editor, 31st December, 1922; issued separately, 6th June, 1924.*]

Plates 11–15.

Family STRUTHIOLARIIDAE Fischer, 1884.

PART I.—GENERIC CLASSIFICATION.

IN his invaluable *Essais de Paléoconchologie comparée*, Cossmann (1904, p. 106) tabulates the family as follows:—

Genus.	Subgenus.	Section.
Struthiolaria.	*Struthiolaria.*	*Struthiolaria.*
Beak short, adjacent to the basal sinuosity.	Columellar margin thin and wide.	Lip bisinuous.
		Struthiolariopsis Lip unknown.
	Pelicaria. Thick layer of enamel on the spire.	*Pelicaria.* Sutural excavation.

In addition there is *Struthiolarella* Steinmann and Wilckens, separated as a subgenus in 1908.

Zemira H. and A. Adams was placed in the family by Hedley (1899, p. 118) because of the curved columella and the presence of a spur on the outer lip, but the nature of the latter is quite different from that of the projection on the lip of *Struthiolaria.* The little spur on the lip of *Zemira* owes its origin to the spiral channel on the anterior portion of the body-whorl, as in *Ancilla* and *Pseudoliva*; but in *Struthiolaria* there is no spiral channel, the two projections on the outer lip not being dependent on the spiral sculpture. In addition the opercula are different, so it does not seem advisable to include this genus in the Struthiolariidae.

STRUTHIOLARIOPSIS Wilckens, 1904.

Genotype: *Fusus ferrieri* Philippi.

The value and systematic position of this genus are by no means established. It was placed in this family because of the strong spirals on the base, thus resembling the South American members. Cossmann rightly considered the creation of the genus on the material available "premature," as the aperture was unknown. The excellent figure (Wilckens, 1904, pl. 18, fig. 5), however, shows that the course of the growth-lines of the outer lip is the same as that of *Belophos*, which has many Tertiary representatives in New Zealand. Other features of agreement are the concave shoulder, with fine spirals, much stronger spirals below, and the presence of axial sculpture. A figure of the New Zealand *Belophos*

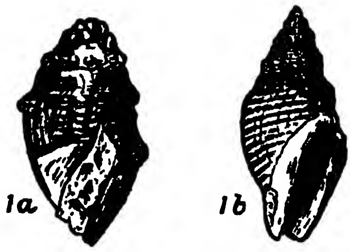


FIG. 1. –*a. Struthiolariopsis ferrieri* (Phil.). (After Wilckens.)
b. Belophos sulcata (Hutton).

cf. *sulcata* (Hutton) is given (text-fig. 1*b*) for comparison with the type of *Struthiolariopsis.* The chief differences observable are the longer axials and the higher whorls of the former.

Another species attributed to this genus is *Struthiolariopsis similis* Wilckens (1922, p. 17), from the Upper Senonian of Amuri Bluff, New Zealand; but unfortunately this shell does not in any way improve the position. Wilckens was not sure whether there was an anterior canal, but the aperture of the type and only specimen has now to some extent been cleared of the hard matrix (see text-fig. 2). The columella is quite straight, and, where broken, the canal shows little taper, so it was originally much longer. This, with the strong biangulation of the body-whorl, the nodules on the shoulder-angle, the course of the growth-lines, and the disposition of the spiral ornamentation, indicates generic, perhaps even specific, agreement with *Tudicula alta* Wilckens, figured by him on the same plate, and occurring at the same locality.

FIG. 2.
"*Struthiolariopsis*" *similis* Wilckens (holotype).

Struthiolariopsis should therefore be removed from the Struthiolariidae and put near *Belophos.* The latter genus was placed by Cossmann (1901, p. 37) in the Buccinidae, but its shape, aperture, and ornamentation show relations with *Pseudotoma*, the only difference being the deeper anterior notch of the canal.

* * * * * * *

The shells hitherto classed under *Struthiolaria* sensu lato present a considerable diversity of appearance, and several well-defined divisions can be made:—

1. *Monalaria* n. g. Outer lip with broad sinus above sweeping round to a convex wing below, columella straight.
   a. Whorls convex, sculpture of equal strong spaced spiral cords. Ex. cf. *S. lirata* Tate.
   b. Whorls with curved axials, crossed by spaced spiral cords. Ex. *S. minor* Marshall.
   c. Early whorls as in *b*, later whorls with fine regular spiral striae, and axials abbreviated to sharp tubercles. Ex. *S. concinna* Suter.
2. *Struthiolarella* Steinmann and Wilckens. Outer lip as in 1, columella slightly bent in youth, curvature increasing with age; whorls subangled, early sculpture of curved axials, later abbreviated to rounded tubercles, fine spirals above, strong cinguli below. Ex. *S. ameghinoi* von Ihering.
3. *Struthiolaria* Lamarck. Outer lip bisinuous, columella bent well to right.
   a. Whorls angled, often tuberculate, sculpture of fine spiral lirae. Ex. *S. papulosa* (Martyn).
   b. An enormous development of callus on inner lip, otherwise as *a.* Ex. *S. callosa* n. sp.
   c. Spire-whorls bicarinate or tricarinate, body-whorl with four principal spiral cinguli and several weaker ones below, cinguli sometimes moniliform. Ex. *S. vermis* Martyn.
4. *Tylospira* Harris. Outer lip bisinuous, columella well bent, lightly calloused at an early stage, but continuing to grow forward so that no sculpture is formed on the body-whorl. Ex. *B. scutulatum* Martyn.

The four main divisions, based on the formation of the aperture, are here given generic rank, and that these genera have sprung from a common stock appears on a study of their ornamentation.

Grabau (1902) was the first to apply the theory of recapitulation to the development of gasteropod sculpture, notably for *Fusus* (1904). Additional groups have been worked out by Miss McDonald, Dr. Trueman (1921), and others.

The following is an attempt to discover the phylogeny of the family by following the ontogeny of some characteristic species.

Well-preserved examples of the Recent and Pliocene *S. papulosa* and *S. vermis* show, in most cases, a small almost planorbid apex of one or two smooth volutions. This has always been considered as the protoconch; but a surprising condition was revealed by some specimens of *S. vermis* from the Wanganuian Pliocene. In these the protoconch is a smooth, bulbous, capuliform structure, with its long axis at right angles to that of the shell (a particularly large and projecting example is figured in text-fig. 3, *a c*). That this is the true protoconch is shown by the

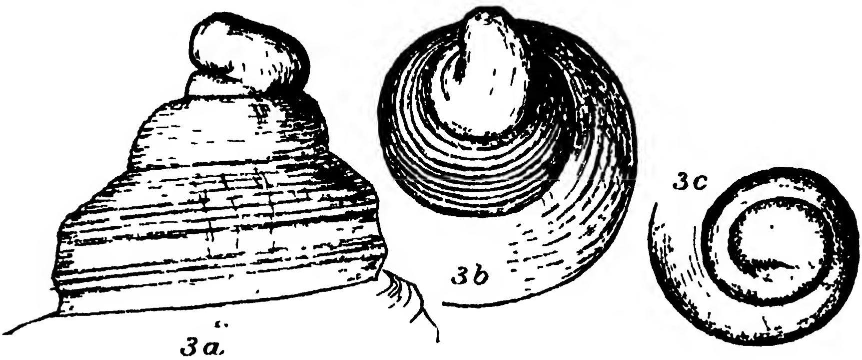


FIG. 3. Protoconch of *Struthiolaria vermis*. × 6.

appearance of the same feature on specimens of *S. convexa* n. sp. from the Pliocene of the Ngaruroro River. In withdrawing from the embryonic shell the animal constructs numerous septa, so that, the hollow bulb being easily broken off, a planorbid apex is the result. It is probable that this type of protoconch prevails throughout the genus, for the smooth planorbid tip, generally seen in all well-preserved shells, is followed by a convex, striated conch-whorl similar to that following the deviated protoconch of the examples cited above.

1. Genus MONALARIA n. g.

Genotype: *Struthiolaria tuberculata concinna* Suter.

(*a.*) *S. lirata* Tate. The first volution of the conch in all species of New Zealand Struthiolariidae is a convex whorl with about six regular spiral threads separated by interspaces of slightly greater width, and, as far as seen, all starting at practically the same time. This indicates that the primitive type from which the various species are descended was a round-whorled shell with strong regular-spaced spirals, a condition well represented by *Struthiolaria lirata* Tate from the Gippsland Lakes (Tate, 1889, p. 169, pl. x, fig. 11). (See text-fig. 4.)

FIG. 4. "*Struthiolaria*" *lirata* Tate. (After Tate's figure.)

The figure shows that this species has a straight columella, and little callus on the inner lip, though the outer lip is thickened. That a certain advance has been made on the primitive type is indicated by Tate's description of secondary spirals in the interspaces of the body-whorl. The growth-lines are stated to be "sigmoidal," which

suggests agreement* with *Monalaria* n. g. (see below) rather than with *Struthiolaria.*

(*b.*) *M. minor* (Marshall). The only apex seen is tectiform, consisting of about two smooth rounded whorls, the top one small and depressed; the nucleus, however, is broken off. The first conch-whorl is convex and has eight spirals appearing simultaneously, but the shell is somewhat weathered at this point. Later the whorl becomes subangled and short, curved axial ribs appear on the upper part of the whorl, not reaching the suture below, while the spirals increase in number. The body-whorl is weakly biangulate, the lower keel having two more prominent cords, the upper of which is moniliform. The outer lip is reflexed and thickened with a broad sinus above, sweeping forward to a prominent rounded wing opposite the lower keel, and then retreating in a shallow sinus to the columella. No specimen showing a complete aperture has yet been found, but, while the columella is twisted, it does not appear to have been bent inwards at the base. (See Plate 11, figs. 5, 6, 7.)

(*c.*) *M. concinna* (Suter). The first two conch-whorls are the typical convex spirally-striated ones common to the apices of the family, and the next two show a fine development of the curved axial ribs crossed by the primary spirals with secondaries appearing in the interstices; that is stage (*b*) as typified by *M. minor.*

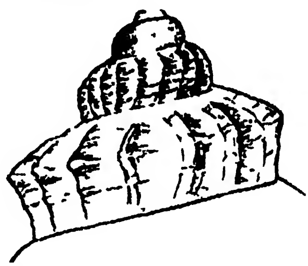


FIG. 5.—Apex of *Monalaria concinna* (Suter). × 3.

On succeeding whorls the axials are much abbreviated, forming strong sharp tubercles on a well-developed shoulder-angle. The body-whorl has, in addition, a double lower keel armed with more closely set tubercles, while the spirals have become numerous fine regular threads. The columella is straight and comparatively little calloused, while the contour of the outer lip is exactly the same as that of *S. minor*—*i.e.*, it is unisinuous.

2. Genus STRUTHIOLARELLA Steinmann and Wilckens, 1908.

Genotype: *Struthiolaria ameghinoi* von Ihering.

This group was separated from *Struthiolaria* as a subgenus (Steinmann and Wilckens, 1908, p. 53) for the reception of the South American species, on the grounds that they differed from the typical New Zealand shells as follows: (1) "On the older whorls spiral sculpture does not predominate, but axial ribs, which are, it is true, crossed by fine spirals"; (2) "there is no continuous spiral angle formed on the upper part of the whorls." Other important features justify the separation. Ortmann's figure of *S. ornata* (1901, pl. 33, fig. 12*a*), reproduced below (text-fig. 6, *a*), shows convex whorls with the curved axial ribs crossed by spirals as in *Monalaria*,

* A new genus seems to be required for *S. lirata* because of the different sculpture from *Monalaria.*

while on the base are two strong spiral cords. Other and more developed species of the group show the axials abbreviated to rounded tubercles with many strong spirals below. The columella is in most cases only slightly bent; but in *S. nordenskjoldi* Wilckens the curvature is marked, and the callus is well developed, showing that a gerontic stage has been reached. In all cases the outer lip has the same contour as that of *Monalaria*—*i.e.*, there is one prominent sinuosity.

The development of strong spirals on the base shows that this group branched off from *Monalaria* sensu lato before the development of such as *M. concinna*, but it may have come through *M. minor*. The age of these two species cannot definitely be placed on the European time-scale, but the probabilities are that the latter is about Palaeocene and the former Oligocene. The curvature of the columella and the spread of the callus in mature

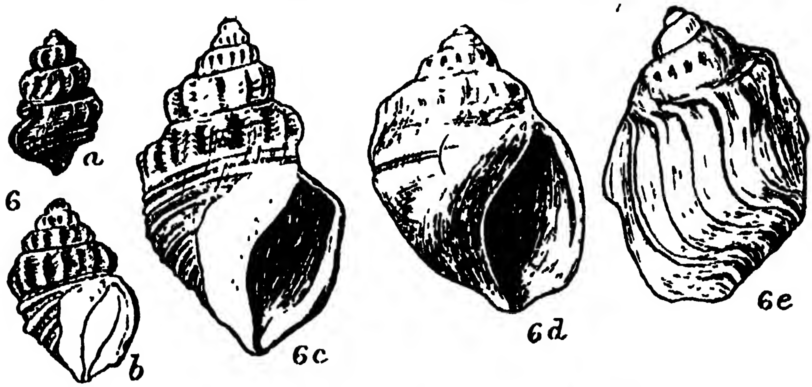


FIG. 6.—*a, b. Struthiolarella ornata* (Sowerby). (After Ortmann.)
c. S. ameghinoi von Ihering. (After Ortmann.)
d, e. S. nordenskjoldi Wilckens. (After Wilckens.)

individuals—see Steinmann and Wilckens, 1908, figures of *S. ameghinoi*, pl. 6, fig. 7, and *S. nordenskjoldi* Wilckens, 1911, pl. 1, figs. 26, *a, b*—in addition to the strong basal spirals, justify the generic separation of *Struthiolarella* from *Monalaria*, while the contour of the outer lip and the ornamentation separate it from *Struthiolaria*. Wilckens later (1922, p. 17) tentatively suggested that *S. nordenskjoldi* was wrongly classed with *S. ameghinoi*, and was more closely related to *Conchothyra parasitica*. The writer does not agree with this, and considers *S. nordenskjoldi* to be a gerontic development of *Struthiolarella*.

Under *Struthiolarella*, Steinmann and Wilckens included *Tylospira coronata* (Tate) from the Lower Tertiary of Victoria, and the living *Struthiolaria mirabilis* Smith from Kerguelen Land, not granting generic recognition to *Tylospira* as based on *B. scutulatum*. Previously Tate (1889, p. 170) had included the Kerguelen shell with *T. coronata* and *T. scutulata* in his interpretation of the genus *Pelicaria* (*i.e.*, *Tylospira*).

FIG. 7.
Struthiolarella mirabilis (Smith).
(After Tryon.)

Though the apertural callus is lacking, *S. mirabilis* certainly is similar to *S. ameghinoi*, and is perhaps rightly associated with *Struthiolarella*; but

the case for the inclusion of *T. coronata* is not so good, because it involves the separation of that species from *T. scutulata* and *T. clathrata*.

It is necessary, before going further, to determine what relative importance should be conceded to the various shell-characters. Roughly, the order of importance may be stated as first, the formation of the aperture; second, the ornamentation; third, the disposition of the callus. (The protoconch is, of course, very important in classification, but the material available does not allow of its use in the present case.) Naturally, the rule cannot be applied absolutely, because a small difference in the aperture might not carry the same weight as a considerable difference in sculpture; also, the possibility of parallelism and convergence must be taken into account. Still, there is a broad relative value attached to the features mentioned.

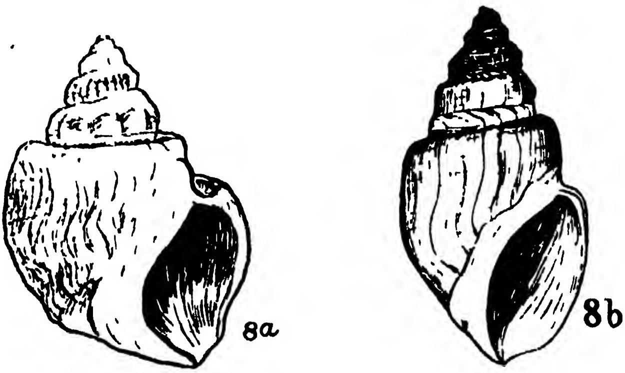


FIG. 8.—*a. Tylospira coronata* (Tate). (After Tate.)
b. Tylospira scutulata (Martyn).

As regards the generic position of *T. coronata*, an examination of actual specimens shows that it cannot be separated generically from *T. scutulata*, the type of *Tylospira*. Both species have a bisinuous outer lip which is not reflexed in the adult. In late youth this lip acquires a shining callus which, continuing across the suture, ascends the wall of the preceding whorl. Unlike Struthiolaria, growth continues for a considerable time after the formation of this callus, so that no ornamentation except growth-lines and a few obsolete spirals is developed on the body-whorls. If Steinmann and Wilckens were correct in classing *T. coronata* as *Struthiolarella*, then *T. scutulata* would also have to be included, and *Tylospira* would supersede *Struthiolarella*. The former genus, however, has a bisinuous outer lip, while the latter has a unisinuous one, so that the two generic terms should stand, *Tylospira* for the Australian and *Struthiolarella* for the South American species.

3. Genus Struthiolaria Lamarck, 1812.

Genotype: *Buccinum papulosum* Martyn.

(*a.*) *S. papulosa* Group.

The apex consists of about two smooth whorls, the first planorbid; but, as pointed out above, these may not represent the true protoconch.

The first conch-volution of the type species is the usual convex one with five or six spirals. Three finer exogeneous spirals (Grabau, 1902) then appear, while at the posterior primary spiral the whorl shows a slight

angulation that gradually becomes stronger and bears nodules formed by the intersection of the growth-lines. On later whorls these nodules become more prominent and farther apart, finally developing into prominent tubercles, and numerous secondary endogeneous spirals appear The stage of curved axial ribs so characteristic of *Monalaria* is not represented, so this is probably a case of lipopalingenesis, or the dropping of an ancestral stage in the ontogeny of a specialized group (Grabau, 1904, p. 3; Trueman, 1922, p. 141).

About the third conch-whorl of *S. subspinosa*, *S. cincta*, and some others of the group, a faint spiral cingulum appears half-way between the shoulder and the suture. This disappears after one or two volutions, but, together with the angled shoulder, it may represent the stage at which

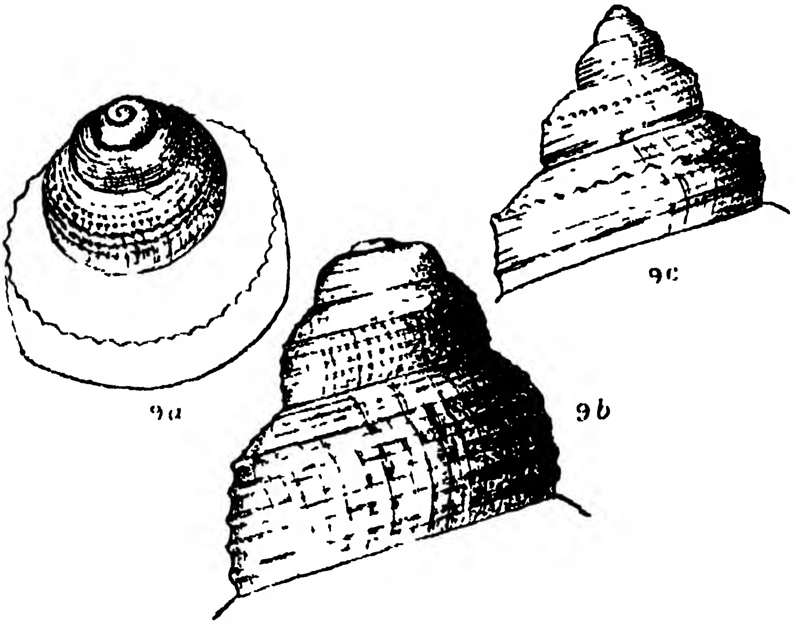


FIG. 9.—*a.* Apex of *Struthiolaria papulosa*; × 6. *b.* Same; × 12. *c. Struthiolaria subspinosa*; × 3.

diverged the *S. vermis* group, with its bicarinate spire-whorls. This bicarination has practically disappeared from the early whorls of *S. papulosa*, but some specimens have a suggestion of it.

Traces of the double lower keel of *M. concinna* linger in some specimens of *S. subspinosa*, but in the other Miocene species, such as *S. spinosa*, this keel is single, while in the Pliocene and Recent *S. papulosa* it has disappeared, leaving only one angulation—*i.e.*, at the shoulder of the body-whorl.

More profound changes from the *Monalaria* stage are to be seen in the curved columella, and the appearance of a second angulation on the outer lip, opposite the posterior keel (or shoulder-angle). Indeed, these features may indicate that *Struthiolaria* s. str. did not descend through *Monalaria*, but that the two are independent branches of an earlier convex-whorled ancestor. This would mean that the body-whorls of *M. concinna* and *S. subspinosa* are parallel developments, but their close agreement in details of sculpture points rather to direct descent of the latter from the former.

This resemblance is so close that Suter granted only varietal rank to *M. concinna*, though why he considered it a variety of *S. tuberculata* is hard to understand.

(*b.*) *S. callosa* Group.

At different localities in the rocks of Upper Miocene and perhaps Lower Pliocene age there are several species of *Struthiolaria* which have a somewhat strange appearance. These shells agree with *Struthiolaria* s. str. in all essential features, but there is a huge development of the rather flat pad on the inner lip. This callus-pad surmounts the shoulder, even burying the long tubercles, generally reaching the posterior suture, but rarely adhering to the whorl above. On the outer part of the base the pad protrudes and has a vertical face exteriorly; but between this knob and the anterior beak is a deep smooth channel with only a thin layer of enamel. The pad is rounded off somewhat abruptly at its upper junction with the outer lip, forming another channel on the shoulder. The outer lip is thickened and reflexed, but no more so than in the typical *Struthiolaria*. In the sutures on the later spire-whorls a layer of enamel is generally showing, sometimes ascending to the row of tubercles on the shoulder (see Plate 14).

At least four species are represented, but they may not form a natural group distinct from the *S. papulosa* group; for, while *S. callosa*, apart from the callus, agrees closely with *S. spinosa*, *S. armata* appears to be just as closely related to *S. spinifera*. This might mean that the great callus is produced by a parallel development of different species.

The following table gives a suggested ancestry of the species belonging to the two foregoing groups:—

	S. obesa					
S. fortis	*S. callosa*	*S. armata*				*S. frazeri*
			S. tuberculata		*S. cingulata*	*S. papulosa*
	S. spinosa		*S. spinifera*	*S. calcar*	*S. cincta*	*S. errata*
			S. subspinosa			
			M. concinna			
			M. minor.			

(*c.*) *S. vermis* Group.

The shells belonging to this group form a well-defined series attaining considerable development in the Wanganuian (Pliocene) of New Zealand. Only one specimen has been seen from a lower horizon, the Tawhiti series, East Cape, which may be of Upper Miocene age. This shell is much distorted, but there is no doubt that it belongs to the group, being closely allied to *S. acuminata* n. sp.

A study of the neanic shell of *S. vermis* shows that the first conch-volution is regularly convex, with the usual five or six spirals. On the succeeding volutions these become grouped into two cinguli forming a biangulation in the spire-whorls, with numerous secondary spirals (see text-fig. 3). On later spire-whorls in some species (ex. *S. canaliculata*) a third cingulus appears posteriorly.

S. convexa n. sp. has rounded whorls throughout, but there are numerous fine spirals of secondary and higher orders arranged in groups as obsolete cinguli, corresponding to those of related species. It is therefore not so primitive a type as at first might appear.

The characteristic feature of this group is the presence of spiral cinguli which make the spire-whorls bicarinate or even tricarinate; but the cinguli are sometimes obsolete, especially on the body. The spirals are occasionally nodular or moniliform, but are generally smooth, and there are never axial ribs. The aperture differs from most of the *S. papulosa* group in having a definitely limited inner lip of regular width, while the callus of the outer lip is thick and rounded in cross-section. The sinuation of the outer lip is shallow, sometimes obsolete, but the posterior edge of the callus generally shows its bisinuate character, which, with the curved columella, indicates a relationship closer to *Struthiolaria* s. str. than to any of the other groups. If a sectional or subgeneric name is required it will be *Pelicaria* Gray, 1857, with *Buccinum vermis* Martyn as type (see remarks below under *Tylospira*).

As already pointed out, the bicarinate spire is foreshadowed in the third conch-volution of *S. subspinosa* and *S. cincta.*

The canaliculate suture of such species as *S. canaliculata, S. fossa,* and *S. zelandiae* must be considered as a gerontic feature paralleling a similar development in *Tylospira coronata* (Tate).

It is possible that exception may be taken to the specific recognition of some of the forms described below. No subspecific, mutational, or varietal divisions are used in this paper; but it must be understood that the relations between some of the species in a group are much closer than those between others. After all, a species is a purely artificial division, and in palaeontology especially a grading is found between different forms, so that in a good series one can trace the gradual change which produces what is commonly termed a "new species." The placing of the specific boundary must always be a difficulty, and the better the collection the harder it is to decide; but that two different shells can be connected by a series is no reason why the extremes should not be separated specifically, especially if the change goes on throughout a considerable lapse of time.

Although the arrangement proposed in this paper is by no means final, it will be of much more use to the stratigrapher than the previous one.

4. Genus TYLOSPIRA Harris, 1897.

Genotype: *Buccinum scutulatum* Martyn.

Pelicaria was proposed by Gray (1857, p. 97), who gave as the single example, and therefore the genotype, *S. vernis*, for shells with a callus spreading over the body. The division was recognized sectionally by Tryon (1885, p. 134) and subgenerically by Fischer (1887, p. 677), but these authors cited *B. scutulatum* Martyn as an example, and did not mention *S. vernis.* Harris (1897, p. 218) noticed the anomaly, and thought *S vernis* to be a misprint for *S. vermis* (Martyn). Consequently *Pelicaria* became synonymous with *Struthiolaria*, so he proposed *Tylospira* with genotype *B. scutulatum* Martyn for the calloused species. This proceeding was not approved by Cossmann (1904, p. 106), who argued that Gray, "who knew perfectly well *S. vermis* and *B. scutulatum,*" would not have created a new genus for the former, which is nearer to the true *Struthiolaria* than is the latter.

In support of this he states that "all authors (Tyron, Zittel, Fischer) have admitted, till now, *S. scutulata* as the type of *Pelicaria.*" The latter

argument does not apply, for the mere citing of an example by subsequent writers is not a legal fixation of a genotype (Jukes-Browne, 1909, p. 238), which, in any case, must be one of the original species given by the author. The only way, therefore, in which *Pelicaria* can be accepted for this group is to prove that *S. vernis* is synonymous with *B. scutulatum*.

This synonymity appears to be unlikely; for if Gray was "familiar with both *B. vermis* and *B. scutulatum*," and intended it for the latter, why (1) did he propose a new specific name for it? why (2) did he use a name so likely to be confused with *vermis?* what (3) is the derivation and meaning of *vernis?* It does not appear to be a Latin word.

On the other hand, *S. vermis* does not possess a spreading callus, as stated by Gray, but has a more limited one than *Struthiolaria* s. str., so it seems likely that he was handling a specimen of *T. scutulata* wrongly identified as *S. vermis*. This, however, cannot alter the fact that the only example cited by the author of *Pelicaria*, and therefore the type of that genus, is *S. vermis*. This is confirmed by at least one of the figures that he cited. The original reads, "*P. vernis*, t 5, f 3, t 91, f 6: Adams, *Gen. Moll.* t 27, f 7." The former reference is to *Figures of Molluscous Animals*, by Maria E. Gray (1850–54), a work which unfortunately was not available for this revision. The figure referred to in Adams's work is labelled "*Struthiolaria vermis*," and is a copy of Kiener's figure of that species; *vernis* is therefore a misprint for *vermis*, and *Pelicaria* is synonymous with *Struthiolaria*, as Harris stated. *Tylospira* must be used for the group of calloused shells typified by *Buccinum scutulatum* Martyn, and including the fossils *T. coronata* (Tate) and *T. clathrata* (Tate). (See text-fig. 8 and remarks above under *Struthiolarella*.)

Both Tryon and Cossmann give only New Zealand as the locality for *T. scutulata*, and consequently cite *Pelicaria* (= *Tylospira*) as a New Zealand genus. This is not correct. *T. scutulata* is a New South Wales shell (Tate, 1889, p. 170), and does not occur in this country, so that the genus *Tylospira* must be considered as exclusively Australian. The peculiar formation of the body-whorl by continued growth of the outer-lip callus, as well as the arched columella and sharp beak, justify generic distinction from *Struthiolaria*.

Phylogeny of the Family.

From the foregoing it will be seen that all the members of this family have descended from a convex-whorled ancestor with fairly strong, spaced spirals, probably of Cretaceous age. "*Struthiolaria*" *lirata* Tate, which has been cited above as an example, is probably far in advance of the primitive form, but gives a general idea of what its appearance must have been.

In the next stage, that illustrated by *M. minor*, there are strong axial ribs which curve forward anteriorly, following the shape of the outer lip. This species presents a remarkable similarity to the young uncalloused stage of the Upper Senonian *Pugnellus marshalli* Trechmann (1917, p. 302, pl. xix, figs. 1–4), which Wilckens (1922, p. 14) considers conspecific with *Conchothyra parasitica* Hutton. The specimen of *P. marshalli* figured below (text-fig. 10), a paratype, shows by growth-lines that the contour of the outer lip of early stages was almost identical with that of *Monalaria*, the wing being a little narrower (see text-fig. 10). The other features also correspond, for the columella is straight, and the ornamentation consists of axially-elongated tubercles on the shoulder and

two weak cinguli below, fine spirals covering the whole surface. Later in life the shell is heavily calloused (*C. parasitica* is completely covered), the wing is more prominent, and the columella curved. This condition shows that a gerontic stage has been reached, so that it is unlikely that *Monalaria* is a direct descendant of *Conchothyra*. The ontogeny shows, rather, that both had a common origin, but that *Conchothyra* became much more specialized and soon died out, while the *Monalaria* stock persisted.

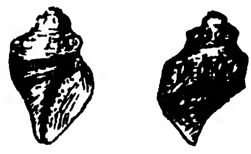


FIG. 10.
Conchothyra marshalli Trechmann (juv.): Selwyn Rapids. Compare with *Monalaria minor* (Plate 11, figs. 5, 6, 7).

The next development was a shortening of the axial ribs into tubercles, accompanied by evolution of the spiral sculpture along two different lines—(1) fine equal spiral lirae on a bicarinate body, (2) strong cords below a tubercled shoulder.

The former retains the straight columella and is the typical *Monalaria* (in which the previous stage is here included generically); but in the latter, *Struthiolarella*, the columella becomes curved, and a considerable callus forms in some species.

In *Struthiolaria* s. str., which seems to date from the early Miocene or late Oligocene, there is a change in the outer lip, which becomes bisinuous, the columella is well curved, and the callus generally well developed. Sometimes it is enormously so, but these highly specialized forms did not last long. The history of the *S. vermis* group is somewhat uncertain; the apertural characters are the same as those of *Struthiolaria* s. str. (*i.e.*, the *S. papulosa* group), but the ornamentation is of a very different nature, and in the course of its development shows none of the preceding stages except the first convex one. The appearance of a somewhat similar bicarination is, however, seen in young whorls of some of the Miocene *Struthiolaria* s. str., so it is possible that the *S. vermis* group diverged during early Miocene or late Oligocene times. As its appearance before the Pliocene is very brief, it is possible that the divergence was caused by isolation, which ended towards the close of the Miocene.

Tylospira, with its much-curved columella and peculiar callus, is evidently an advanced genus. The bisinuous outer lip would seem to connect it with *Struthiolaria*, though its early appearance in the Tertiary shows that it is not descended from that group. Perhaps both sprang from an earlier common ancestor, slightly in advance of *Monalaria*. A study of the ontogeny of the Australian species might throw some light on this point.

An analysis of the published lists of New Zealand Tertiary Mollusca, with a view to finding the stratigraphical range of the different species, gives a result quite disheartening to the stratigrapher. According to these lists, many species range from the bottom to the top of Oamaruian, and even into Wanganuian and Recent times. As accurate correlations with European stages or even systems cannot yet be made, such results are liable to force all New Zealand Tertiary strata into one horizon. There is already a tendency in this direction, for several geologists have put the whole of the Oamaruian into the Miocene.

STRATIGRAPHICAL DISTRIBUTION

PALAEOCENE	OAMARUIAN Oligocene (perhaps Upper Eocene)—Miocene				WANGANUIAN Pliocene			RECENT
Wangaloan	Bortonian	Upper Waiarekan Ototaran and Hutchinsonian	Awamoan	Mokau Series, &c	Waipipian	Nukumaruian	Castlecliffian	
M. minor	*M. concinna*	*M. concinna* (?) *S. subspinosa* (?)	*S. subspinosa*	*S. subspinosa*	*S. cincta* *S. cingulata* *S. errata* *S. papulosa*	*S. frazeri* *S. papulosa*	*S. papulosa*	*S. papulosa*
			S. spinosa *S. tuberculata* *S. calcar* *S. spinifera*	*S. callosa* *S. fortis* *S. armata* *S. obesa*				
				S. cf. *acuminata* (Tawhiti Series)	*S. canaliculata* *S. monilifera* *S. zelandiae* *S. rugosa*	*S. acuminata* *S. vermis* (?) *S. parva* (?) *S. fossa* *S. convexa* *S. media*	*S. tricarinata* *S. vermis*	*S. tricarinata* *S. vermis*

The position is by no means so confused as the fossil-lists would show, but it is a difficult matter to supply an absolute proof, especially as the evidence is largely negative. It is impossible, for instance, to take all the records of *S. papulosa*, and to establish the correctness or incorrectness of each identification. But since, in the extensive collections examined from many localities during the course of this revision, a very definite sequence of species was observed, it is a fair inference that such stratigraphical limits prevail throughout the country.

Previous to the appearance of Suter's bulletins the identification of Tertiary Mollusca from Hutton's catalogue was pure guesswork, and the greatest credit must be given to Mr. Suter for the improvement he effected in the status of New Zealand Tertiary palaeontology. It must, however, be recognized that, owing to the great amount of ground covered, many of his specific usages were applied too widely, while in some cases, through bad material, altogether wrong identifications were made.

The table giving stratigraphical ranges of species of *Struthiolaria* on page 172 is therefore based on identifications made during the course of this revision only, and, except where correlations of South Island Pliocene localities are concerned, is claimed to give fairly accurately the stratigraphical limits of the different species.

For valuable help in the preparation of this paper by the loan of specimens, &c., my thanks are due to the following: Miss M. K. Mestayer, Dr. J. Henderson, Professor R. Speight, Messrs. H. J. Finlay, the late R. Murdoch, and W. R. B. Oliver; also to Mr. P. G. Morgan, Director of the Geological Survey, for his permission to publish.

PART II.—SPECIFIC CLASSIFICATION.

1. Genus MONALARIA n. g.

Genotype: *Struthiolaria tuberculata* subsp. *concinna* Suter, 1917.

Shell somewhat small, ovate, umbilicus closed in the adult, conch-whorls at first spirally lirate, later with curved axial ribs, and finally keeled and tuberculate; outer lip reflexed, thickened, concave above, then produced in a sweeping curve into a broad rounded wing opposite the lower keel, columella straight, aperture produced into a short widely-open canal.

This genus differs from *Struthiolaria* in the contour of the outer lip, and the presence of a straight columella.

Monalaria concinna (Suter), 1917. (Plate 11, figs. 1, 2, 3.)

1917. *Struthiolaria tuberculata* Hutton subsp. *concinna* Suter, *N.Z. Geol. Surv. Pal. Bull. No. 5*, p. 9, pl. ii, fig. 9.

Shell rather small; ovate; spire broad, gradate, a little over half the height of aperture; whorls 6, later ones strongly shouldered; sculpture, first 2 conch-whorls convex, with 5 strong but narrow spiral ridges with wide interspaces, on third whorl they are reticulated by curved axials slightly stronger and wider apart than spirals, 3 posterior spirals much finer than other 5; fourth whorl strongly angled with wide shoulder, a fairly strong spiral thread on angle, 3 above and 2 below of equal strength, and, between these, 2 finer spirals with wide interstices in all cases; there are 13 strong rounded axials which commence a short distance from suture and are arched, anterior end being slightly in advance, they are not so

strongly curved as axials of earlier whorl, but are much more prominent; on the penultimate whorl spirals are same as before, but axials have rather the appearance of tubercles on angle of shoulder; body-whorl is spiralled by fine regular threads with wider interstices, the row of tubercles seen on the penultimate whorl continues with unabated strength, and below this is a double keel consisting of 2 rows of low tubercles which do not correspond to those of shoulder nor with each other; suture impressed; aperture inclined, ovate with a short truncated canal below; outer lip reflexed, thickened, concave above, but well produced at lower keel, retreating somewhat rapidly in a shallow sinus to anterior canal; inner lip very moderately calloused; columella straight, ending in a short beak.

Holotype in the collection of New Zealand Geological Survey.

Height, 31 mm.; diameter, 23 mm.

Localities. Waihao greensands (holotype, J. A. Thomson); 176, 933, Black Point, Waitaki Valley; 164, greensands above coal-beds, Kakahu; 487, above coal-beds, Ngapara; 27, roof of upper coal-seam, Ten mile Creek, north of Grey River.

The last two identifications are based on casts, and so may be of shells slightly different from *concinna*, but as far as can be seen they are specifically identical. It will be observed that the beds at all these localities are of a uniformly low horizon, so that this species will be of great value for zoning purposes because of its wide distribution.

For the subspecific relationship with *Struthiolaria tuberculata* nothing can be put forward as evidence. The shells are far apart; indeed, the apertures are so different that the distinction is of generic importance.

Several specimens show an earlier lip, after the formation of which the animal continued building its shell in the usual way. One such lip on the holotype is a complete whorl behind the present aperture, while a specimen from Black Point has a quite complete thickened lip one-third of a turn behind the final one.

Suter (1917, p. 9) mentions the cast of another specimen showing a fourth row of nodules, and concludes therefrom that *S. tuberculata* may have two, three, or four keels. This quite ignores other and much more important characters, for the cast with the four nodules is that of a *Galeodea* cf. *senex* (Hutton).

Monalaria minor (Marshall). (Plate 11, figs. 5, 6, 7.)

1917. *Struthiolaria minor* Marshall, *Trans. N.Z. Inst.*, vol. 49, p. 451, pl. 34, figs. 12, 13.

Localities.—Wangaloa (type); Boulder Hill, near Dunedin (H. E. Fyfe).

The exact horizon with reference to the European time-scale has not yet been worked out, but it is probably lowest Tertiary. (For description of the sculpture, see above, p. 164.)

2. Genus Struthiolaria Lamarck, 1812.

Genotype: *Buccinum papulosum* Martyn.

Shell ovate, umbilicus closed in adults; spire about same height as aperture which is oval, with slight posterior channel and very short truncated anterior canal; columella bent to right, ending in a beak; outer lip bisinuous, reflexed and thickened; inner lip with well-developed callus; protoconch probably bulbous, at right angles to axis, but generally destroyed, leaving a smooth planorbid apex.

In previous descriptions *Struthiolaria* has always been described as imperforate. A section of the columella, however, shows that it is hollow, and therefore the genus must be considered as umbilicate, but with the umbilicus closed in adults by the callus of the inner lip.

(*a.*) *S. papulosa* Group.

Struthiolaria subspinosa n. sp. (Plate 11, figs. 4, 9, 10.)

Shell of moderate size, ovate, with gradate spire about equal in height to aperture; whorls 8, including protoconch, sharply angled above middle, with a somewhat flat shoulder, whorls immediately after protoconch convex, body-whorl bicarinate, concave between shoulder and lower keel, base very rapidly contracted; apex conoidal, of 2 smooth whorls, nucleus minute, planorbid; sculpture, angle of shoulder furnished with small sharply-pointed laterally-elongated tubercles, 14–20 on body-whorl, 18–25 on the penultimate, and about 30 on each spire-volution; keel of body-whorl obsoletely nodular, and base often with weak cinguli, of which the one nearest keel is sometimes stronger, giving the shell the suggestion of a double keel; the whole surface covered with fine, sharp, spiral threads, with wide interstices, 8 on first two convex whorls, 10 on third, the sixth thread from top being moniliform and marking the subangled shoulder, 7 above the finely-tuberculated shoulder of fourth whorl and 9 below, 9 above and 10 below on fifth, 10 above and 17 below on penultimate, the growth-lines very fine; on early whorls a strong spiral cord midway between angle and anterior suture, making whorl bicarinate; suture linear, not impressed; aperture ovate, angled above, produced below into very short canal; outer lip reflexed, thickened, wedge-shaped in cross-section, sinuous, not greatly produced at shoulder, more so opposite lower keel; inner lip with moderate regular callus, barely surmounting keel, and little wider than outer lip; columella concave, bent to right below, ending in beak.

Type in collection of the New Zealand Geological Survey.

Height, 40 mm.; diameter, 27·5 mm.

Localities. 165, White Rock River, Pareora (type); 170, Awamoa; 475, Mount Harris; 458, Lower Gorge, Pareora; 44, Brewery Creek, Mokihinui River; 577, Pareora beds, Kakahu; Target Gully shell-bed, Oamaru; Pukeuri, Oamaru; Hurupi Creek, Palliser Bay (J. A. Thomson), (two incomplete specimens); shell-bed above upper limestone, junction of Porter and Thomas Rivers, Trelissick Basin (J. A. Thomson); 952, Target Gully; Waikaia (H. J. Finlay).

Remarks.—This is the commonest and most widely spread *Struthiolaria* in the Tertiary. The specimens from higher horizons seem to have a smooth lower keel on the body-whorl.

Poor specimens and casts from the following localities resemble this species, but certain identification cannot be made: 98, brown sandstone, Whangaroa Harbour; 70, Akuaku, East Cape district; 649, Paparoa Rapids; 919, mudstone below upper limestone, Awakino Valley; 1043, grit band, McGovern's Stream, Ohura; 1048, Okahukura tunnel.

Distinguished from *S. spinosa* by the more numerous and finer spines, and the narrow callus of the inner lip. The description was compiled from paratypes as well as from the holotype, which is somewhat worn on the spire.

Many of the Target Gully specimens have an appearance somewhat different from the typical *S. subspinosa.* They have very small low

tubercles, are of a slender shape and small size, and have a sloping shoulder. It is quite possible that they can be separated as a distinct species. (See Plate 11, fig. 10.)

Struthiolaria calcar Hutton. (Plate 11, figs. 8, 11, 13.)

1873. *Struthiolaria cincta* var. C Hutton, *Cat. Tert. Moll.*, p. 11.
1886. *Struthiolaria calcar* Hutton, *Trans. N.Z. Inst.*, vol. 18, p. 335.
1887. *Struthiolaria calcar* Hutton, *Proc. Linn. Soc. N.S.W.*, ser. 2, vol. 1, p. 216.
1914. *Struthiolaria calcar* Hutton: Suter, *N.Z. Geol. Surv. Pal. Bull. No. 2*, p. 17, pl. 1, fig. 8.

Localities.—Shell-bed, Ardgowan, Oamaru (H. J. Finlay); Ashburton River, Canterbury (H. J. Finlay); Tengawai Cliffs, South Canterbury (Canterbury Museum).

Hutton gives as the original locality "Oamaru"; and, although the horizon cannot be stated definitely, it was probably Awamoan. Mr. Finlay has some fine specimens from the Ardgowan shell-bed and from the Ashburton River.

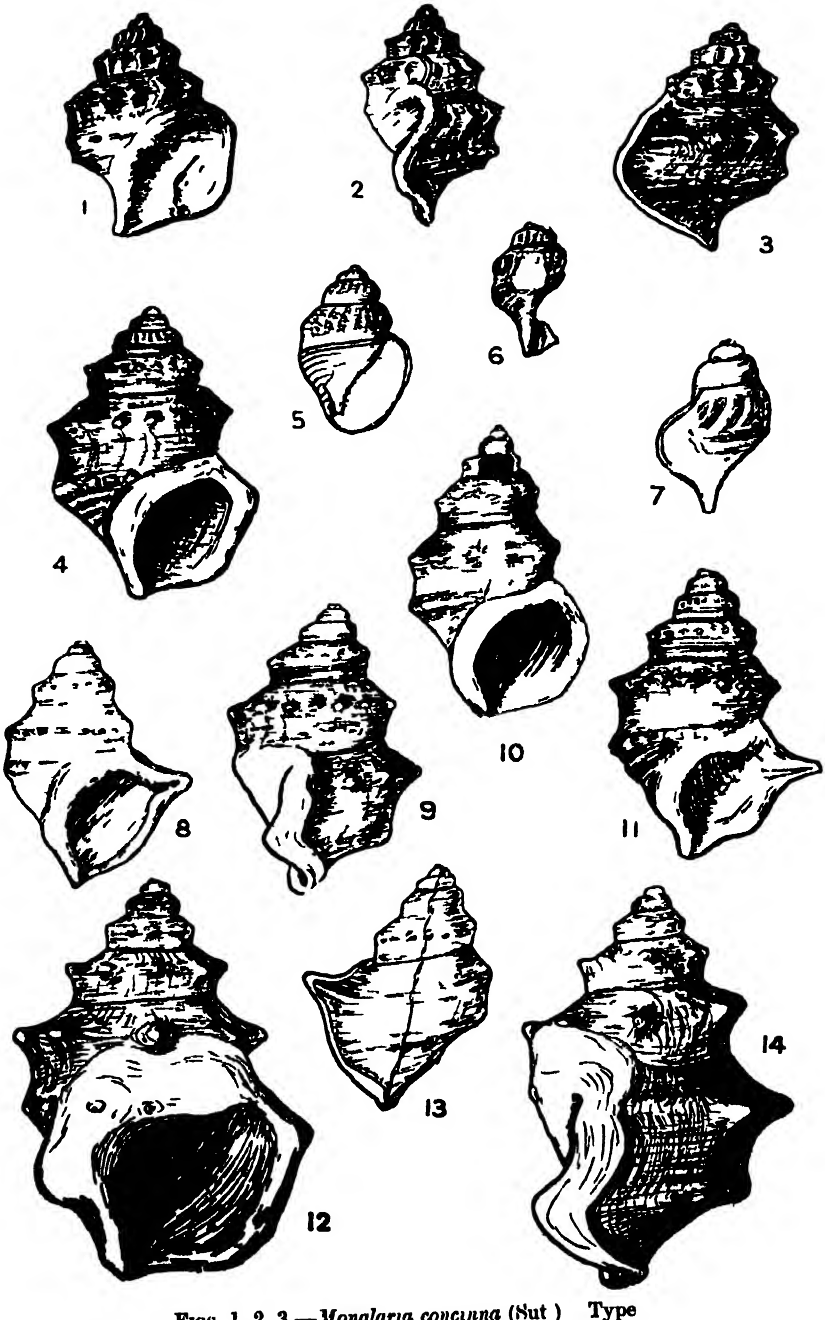
In all respects except the spur on the outer lip these shells are identical in appearance with *S. subspinosa*. Further, just as there are two forms of that species, a broad and a slender, so there are two similar forms of *S. calcar*. It is unlikely, however, that such a development should not have specific value.

The specimen described by Suter as Hutton's type is an artificial, plaster cast, and no trace of the original material now remains. Suter did not notice the nature of the "holotype," for he says (1914, p. 17), "protoconch and all the whorls covered by a white calcareous layer obscuring the sculpture." In view of this Mr. Finlay's specimen from Ardgowan shell-bed (Plate 11, fig. 11) is here named "neotype." If, as seems probable, the plaster cast mentioned above was prepared directly from the original material it is a plastotype (Schuchert, 1905, p. 15); but there is no way of proving this.

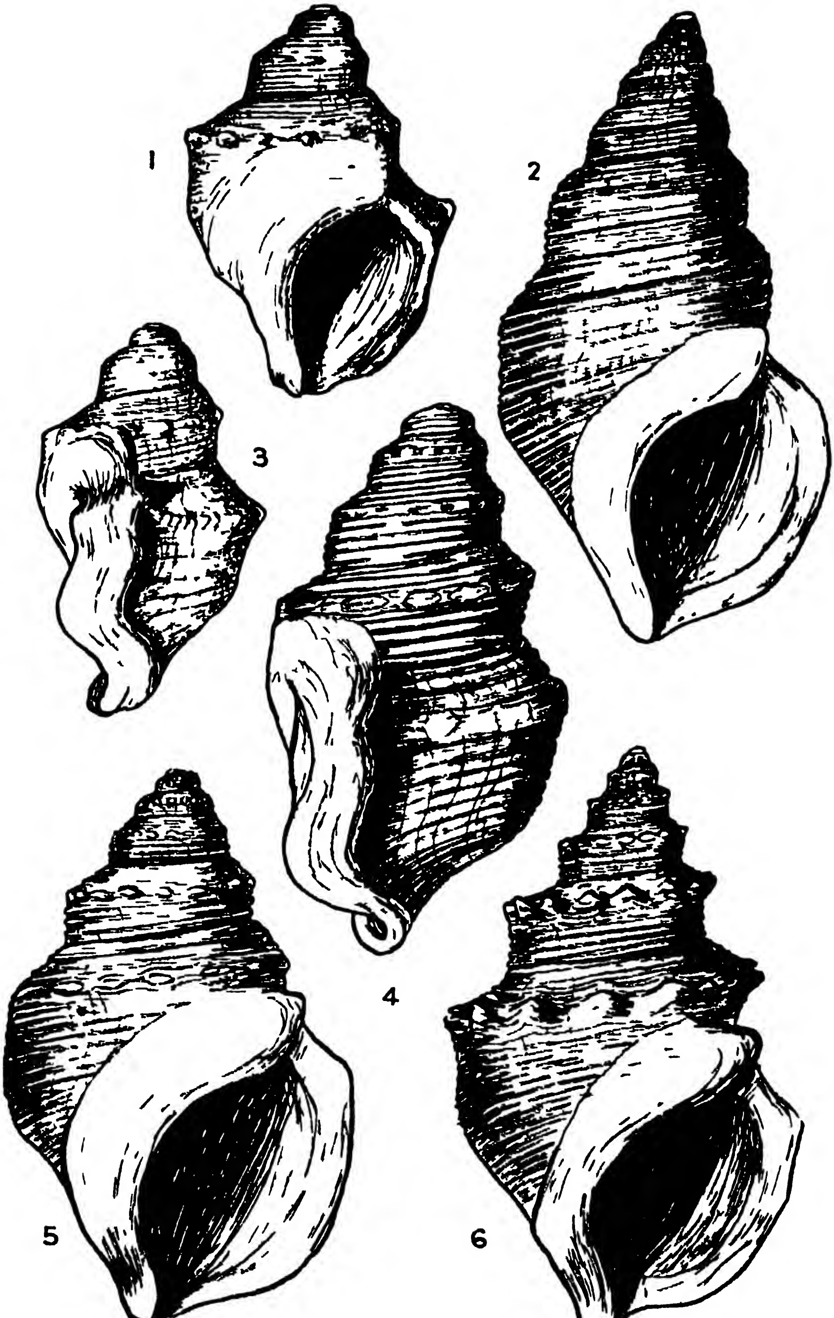
Struthiolaria spinosa Hector. (Plate 11, figs. 12, 14.)

1886. *Struthiolaria spinosa* Hector, *Outline N.Z. Geol.*, p. 51, fig. 9, No. 13.
1886. *Struthiolaria tuberculata* Hutton, *Trans. N.Z. Inst.*, vol. 18, p. 335, in part (not of 1873).
1887. *Struthiolaria tuberculata* Hutton, *Proc. Linn. Soc. N.S.W.*, ser. 2, vol. 1, p. 216, in part (not of 1873).

Shell moderately large, ovate, turreted; whorls 7, strongly shouldered, body-whorl bicarinate; sculpture, the whole surface finely regularly spirally lirate, about 10 lirae on shoulder and 10 between angle of shoulder and suture below, on shoulder-angle is row of long, strong tubercles, 8 per whorl on neotype but 10 on some specimens, generally more numerous on earliest whorls; body-whorl provided with tubercled keel, just below level of suture, in this case tubercles are smaller and closer together than those of shoulder; suture linear, not impressed; aperture oblique, ovate, with shallow channel above and very short canal below; outer lip reflexed, thickened, sinuous, little produced at shoulder but well produced at keel, then retreating rapidly to canal; columella concave, ending in beak directed towards right and front; inner lip with very thick pad of callus which extends up to angle of shoulder, filling in spaces between tubercles and extending over part of base where it presents prominent protuberance with vertical face towards outside and wide smooth channel between it and beak.



Figs 1, 2, 3 —*Monalaria concinna* (Sut) Type
Figs 4, 9 —*Struthiolaria subspinosa* n sp Type
Figs 5, 6, 7.—*Monalaria minor* (Marshall)
Figs 8, 13 —*Struthiolaria calcar* Hutton's plastotype
Fig 10 —*Struthiolaria subspinosa* n sp Target Gully
Fig 11 —*Struthiolaria calcar* Hutton Neotype
Figs 12, 14.—*Struthiolaria spinosa* Hector Neotype



FIGS. 1, 3.—*Struthiolaria errata* n. sp. Type.
FIGS 2, 5, 6.—*Struthiolaria papulosa* (Martyn). Recent
FIG 4 —*Struthiolaria papulosa* (Martyn). Mangatahi River

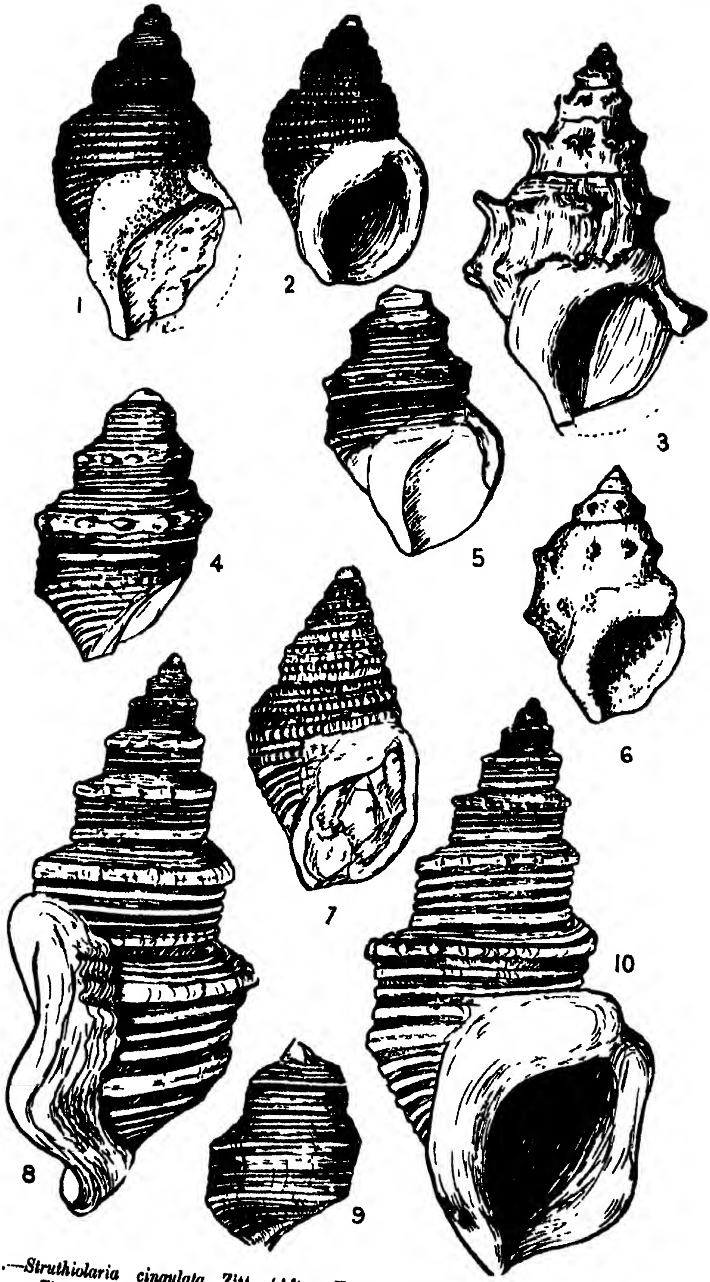
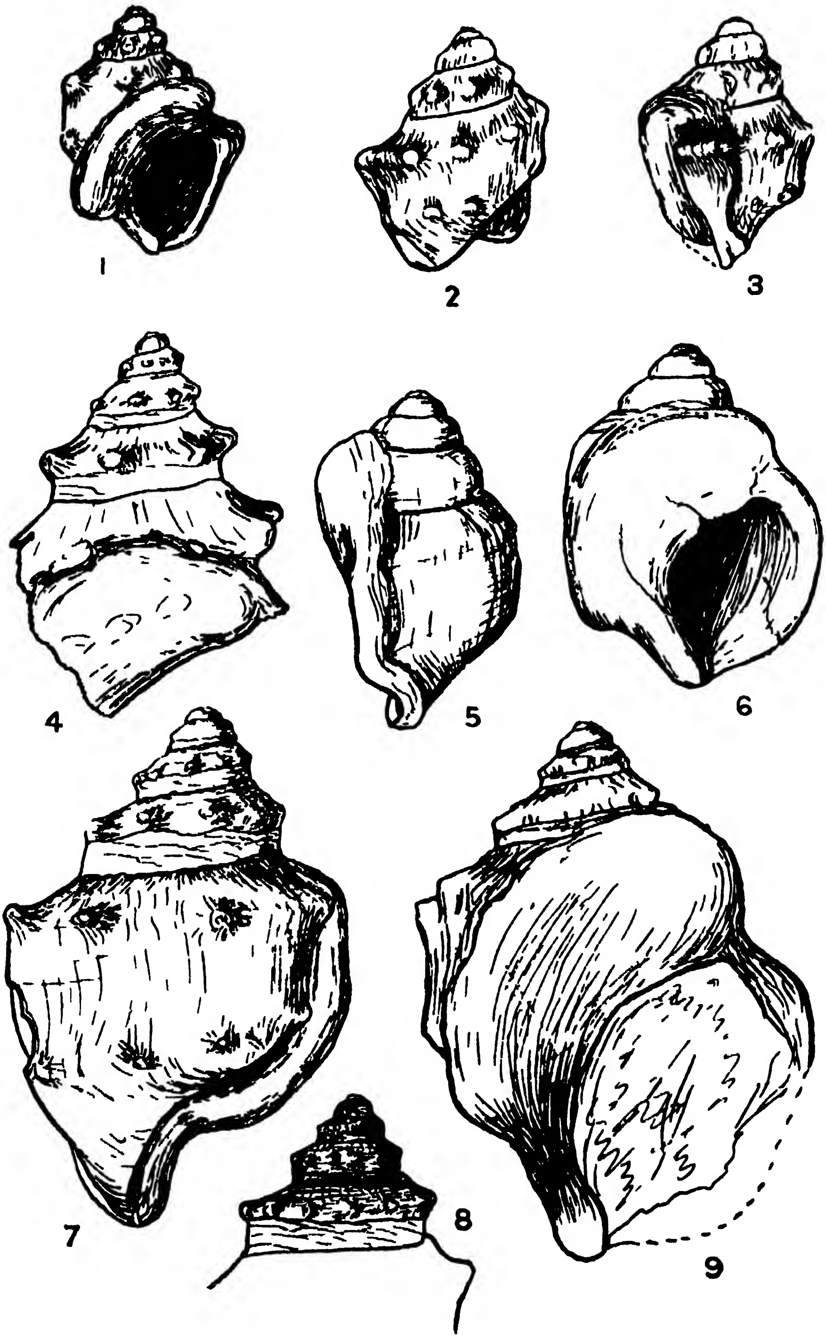


Fig. 1.—*Struthiolaria cingulata* Zitt. (After Zitt.)
Fig. 2.—*Struthiolaria rugosa* n. sp. Type.
Fig. 3.—*Struthiolaria spinifera* n. sp. Type.
Figs. 4, 5.—*Struthiolaria cincta* Hutt.
Fig. 6.—*Struthiolaria tuberculata* Hutt.
Fig. 7.—*Struthiolaria monilifera* Sut. Type.
Figs. 8, 10.—*Struthiolaria frazeri* Hutt. Maraekakaho.
Fig. 9.—*Struthiolaria cingulata* Zitt. (usual form).



Figs. 1, 2, 3.—*Struthiolaria fortis* n. sp. Type.
Fig. 4.—*Struthiolaria armata* n. sp. Type.
Figs. 5, 6.—*Struthiolaria obesa* Hutt. Type.
Figs. 7, 8, 9.—*Struthiolaria callosa* n. sp. (Fig. 7 is type.)

Neotype in collection of New Zealand Geological Survey.
Height, 55 mm.; diameter, 40 mm.

Localities.—165, White Rock River, Pareora (type); Ardgowan shell-bed (H. J. Finlay).

As pointed out by Thomson (1913, p. 25), Hutton illegally introduced *S. spinosa* (1886) as being more appropriate for his *S. tuberculata* (1873). Thus *S. spinosa* Hutton (1886) is an absolute synonym of *S. tuberculata* Hutton (1873). But in the same year (1886) Hector published a figure labelled "*S. spinosa.*" No locality is given, but the drawing (text-fig. 11) is a very fair representation of the common White Rock River species, which is quite different from Hutton's *S. tuberculata* var. B, the shell to which *tuberculata* proper was transferred by that author in 1886.

FIG. 11.
Struthiolaria spinosa Hector.
(After Hector's figure.)

The validity of Hector's specific name and the application of it depend upon whether his publication was prior to Hutton's, which was issued in May. Hector's *Outline* shows only the year of issue, but as the Indian and Colonial Exhibition, for which it was prepared, commenced in May it is safe to assume that the publication of the catalogue was earlier in the year than that of the *Transactions.*

Suter's usage of *S. tuberculata* for the Broken River species is correct; but he made a serious mistake in connection with the type of *S. spinosa.* Hutton (1873) listed *S. tuberculata* var. B, giving the localities "Palliser Bay; Waikari; Lower Gorge of Waipara." The specimen in the show-cases, and therefore the one to be taken as type of *S. tuberculata* var. B, is from Waikari. Both Hutton and Suter thought the White Rock River shell was specifically the same as this one, but their opinions must have been formed without a close examination of the shells, for the body-whorl of the former has a second row of prominent tubercles. A comparison of the figures here published will show the difference at once. *Struthiolaria spinosa* must be based upon the shell that Hector figured—*i.e.*, the White Rock River species; while a new name must be applied to the Waikari one. (See below, *S. errata* n. sp.)

Struthiolaria spinifera n. sp. (Plate 13, fig. 3.)

Shell moderately large, conoidal, with high turreted spire, 1½ times height of aperture; whorls 8, angled above middle with concave shoulder and sloping sides, body-whorl bicarinate, keel of greater diameter than shoulder-angle, base rapidly contracted; apex conoidal, nucleus minute, planorbid; sculpture, first whorls after apex are faintly shouldered, the shoulder-angle of fourth has numerous nodules, while on each of remaining whorls it bears 9 long strong spines, keel of body-whorl also has strong spines, more closely placed but hardly so long as those of shoulder-angle, fine spiral ornamentation is obsolete but growth-lines are strong; suture somewhat undulating, bulging over spines of concealed keel and with narrow strip of callus peeping over it here and there; aperture ovate, subangled above, produced into short canal below; outer lip reflexed, thickened, edge wedge-shaped, sinuous, with fairly prominent projection opposite shoulder-angle and more prominent one opposite keel, inner lip with

moderately wide and regular callus just surmounting keel where it joins outer lip: columella concave, bent to right below and ending in beak.

Holotype in collection of New Zealand Geological Survey.

Height, 55 mm.; diameter, 39·5 mm.

Locality.– 475, Mount Harris (= *S. tuberculata* of *Pal. Bull. No.* 8, p. 64).

Remarks.– The long sharp spines show that this shell is closely related to *S. tuberculata*, from which it differs in its greater size and higher spire.

Struthiolaria tuberculata Hutton. (Plate 13, fig. 6.)

1873. *Struthiolaria tuberculata* Hutton, *Cat. Tert. Moll.*, p. 11.
1886. *Struthiolaria tuberculata* Hector, *Outline Geol. N.Z.*, p. 51, fig. 9, No. 4.
1886. *Struthiolaria spinosa* Hutton, *Trans. N.Z. Inst.*, p. 335 (not of Hector).
1887. *Struthiolaria spinosa* Hutton, *Proc. Linn. Soc. N.S.W.*, ser. 2, vol. 1, p. 217.
1914. *Struthiolaria tuberculata* Hutton: Suter, *N.Z. Geol. Sur. Pal. Bull. No.* 2, p. 19, pl. 1, fig. 12.

Hutton's localities are: "East coast, Wellington; Upokororo Stream, Te Anau Lake; Kawau; Broken Hill (U)." Probably several species were represented; the Broken River shell has become the type because it was represented as the example of the species in Hutton's type collection at the Dominion Museum. Thomson and Speight collected this fossil from the shell-bed immediately above the limestone of Trelissick Basin (Speight, 1917, p. 348); also "in the small tributary of White Water Creek coming in from the north, in what may be called the *Struthiolaria* bed from the number of remains of this genus occurring. The same bed is met with in a similar stratigraphical position in the Porter River between the gorges in the Thomas River." The horizon seems, then, to be low Awamoan. No specimens from elsewhere than the Trelissick Basin have been seen during this revision.

Struthiolaria cincta Hutton. (Plate 13, figs. 4, 5.)

1873. *Struthiolaria cincta* Hutton, *Cat. Tert. Moll.*, p. 11.
1887. *Struthiolaria cincta* Hutton, *Proc. Linn. Soc. N.S.W.*, ser. 2, vol. 1, p. 216.
1897. *Struthiolaria cincta* Hutton: Harris, *Cat. Tert. Moll. Brit. Mus.*, vol. 1, p. 221.
1914. *Struthiolaria cincta* Hutton: Suter, *N.Z. Geol. Surv. Pal. Bull. No.* 2, p. 16, pl. 1, fig. 7.

The type of *S. cincta* is from "Awatere," but the exact horizon was not stated by Hutton. Dr. Thomson's collection from Lower Awatere (*Pal. Bull. No. 8*, p. 30) contains *S. cincta*, so this may be the type locality. The species has been recorded from many horizons — *e.g.*, Kakanui; Waihao greensands; Target Gully; Pakaurangi; Duncan's, Tolaga Bay. These are based either on poor specimens or on a very wide interpretation of the species. The true *S. cincta* has very coarse spirals of irregular appearance, and during the course of this revision has been seen only from 126, Awatere Valley, and 218, Motunau.

The shell most often mistaken for it is *S. subspinosa* n. sp., which has much the same outline, but sculpture consisting of numerous very fine regular spiral lirae, whereas in *S. cincta* the spirals are strong and very irregular. The shoulder-angle of *S. cincta* is sometimes smooth and sometimes ornamented with blunt nodules, 15 to 18 per whorl; in *S. subspinosa* the tubercles are about the same in number, but they are fairly strong and sharply pointed, and are always present.

Struthiolaria cingulata Zittel. (Plate 13, figs. 1, 9.)

1864. *Struthiolaria cingulata* Zittel. *Reise der "Novara,"* 1 Bd., 2 Abt., p. 35, pl. 15, fig. 2.

1873. *Struthiolaria cingulata* Zittel: Hutton, *Cat. Tert. Moll.*, p. 11.

1887. *Struthiolaria cingulata* Zittel: Hutton, *Proc. Linn. Soc. N.S.W.*, ser. 2, vol. 1, p. 217.

1893. *Struthiolaria cingulata* Zittel, *Macleay Mem. Vol.*, p. 61.

1914. *Struthiolaria cingulata* Zittel: Suter, *N.Z. Geol. Surv. Pal. Bull. No. 2*, p. 18 (not the specimen figured pl. 1, fig. 9).

The figure published by Suter was drawn by Buchanan from Hutton's plesiotype from Patea. This shell belongs to the *S. vermis* group, and so is widely separated from Zittel's species. The latter's figure represents an individual with whorls much more convex than usual, but the angulation is described in the text. The more common outline is shown in Plate 13, fig. 9. An examination of the aperture with its spreading callus on the body-whorl, and of the arrangement of the spirals, will show that the species is closely related to the convex variety of *S. papulosa*.

Zittel gives Awatere Valley as the locality, but in this extensive district more than one horizon is represented. The specimens here placed under this species come from Starborough Creek, where the rocks are of Pliocene age.

Suter quotes in his synonymy (1914, p. 18) the *S. cingulata* figured in Hector's *Outline of New Zealand Geology*. This figure was drawn from the type of *S. monilifera* Suter, which was Hutton's variety B of *S. cingulata*, but which belongs to a group different from Zittel's species. It should therefore appear in the synonymy of *S. monilifera*, not of *S. cingulata*. A comparison of Zittel's figure of this species with that published by Suter (drawn by Buchanan from Hutton's specimen) shows that there are important differences. The true *cingulata* has the inner-lip callus wide-spreading and thin on the parietal wall, then tapering rapidly below, with a protuberance about half-way down on the outside. The outer lip is quite thin near the junction with the body. This is the typical *S. papulosa* aperture, and the shell certainly falls under that group. The aperture of Hutton's specimen, on the other hand, has a thick callus of regular width surrounding the aperture; the whorls, too, are convex without the suggestion of carination, and consequently this shell is of the *S. vermis* group. It is described below as *S. rugosa* n. sp.

Although Zittel's figure shows a shell with convex spire-whorls, the body-whorl is obsoletely bicarinate, while in his description (1864, p. 35) he says, "Die Embryonalwinddungen sind glatt, die ubrigen dagegen stumpfkantig . . . die letzte Windung . . . ist mit zwei stumpfen Kanten versehen."

No well-preserved replicas of Zittel's figure have been seen, but there is a common *Struthiolaria* from Awatere which corresponds with the description except that the angles are not blunt (see Plate 13, fig. 9). Perhaps the specimen handled by Zittel's artist was one with exceptionally convex whorls, such as sometimes occur in *S. papulosa*, figured in Plate 12, fig. 2.

According to this interpretation, *S. cingulata* is closely related to *S. cincta*, differing in the presence of regular strong spiral cords, and the absence of tubercles on the shoulder.

Struthiolaria errata n. sp. (Plate 12, figs. 1, 3.)

1873. *Struthiolaria tuberculata* var. B Hutton, *Cat. Tert. Moll.*, p. 11.
1886. *Struthiolaria tuberculata* Hutton, *Trans. N.Z. Inst.*, vol. 18, p. 335 (in part, but not of 1873).
1887. *Struthiolaria tuberculata* Hutton, *Proc. Linn. Soc., N.S.W.*, ser. 2, vol. 1, p. 216 (in part, but not of 1873).
1914. *Struthiolaria spinosa* Hector: Suter, *N.Z. Geol. Surv. Pal. Bull. No. 2*, p. 18, pl. 1, fig. 11 (not of Hector).

Suter has given a full description and figure of this shell, which he wrongfully took to be the type of Hector's *spinosa* (see above, p. 177). The large planorbid protoconch mentioned by him is not the true protoconch of the shell, but is one of the many septa built by the animal in retreating from the summit, which was afterwards broken off.

The species is closely related to *S. papulosa*, but it differs in having a straighter columella and more wide-spreading callus on the body-whorl, which also has larger tubercles, placed farther apart. There is a fairly strong spur at the junction of the shoulder with the outer lip.

Locality.—Waikari.

Struthiolaria papulosa (Martyn). (Plate 12, figs. 2, 4, 5, 6.)

1786. *Buccinum papulosum* Martyn, *Univ. Conch.*, vol. 2, f. 54.
1786. *Buccinum coronarium* Solander, *Cat. Port. Mus.*
1788. *Murex pes-struthiocameli* Chemnitz, *Conch. Cab.* vol. 10, figs. 1520, 1521.
1790. *Murex stramineus* Gmelin: Linn., *Syst. Nat.*, ed. 13, t. 1, pt. 6, 3542.
1822. *Struthiolaria nodulosa* Lamarck, *Anim. s. Vert.*, vol. 7, p. 147.
1835. *Struthiolaria nodosa* Gray, in Yate's *New Zealand*, p. 308.
? 1839. *Struthiolaria sulcata* Jonas, *Arch. f. Nat.*, i. 342, pl. 9, fig. 5.
1842. *Struthiolaria gigas* Sowerby, *Thes. Conch.*, 1, pl. 5, f. 17.
1843. *Struthiolaria papillosa* Martyn: Gray in Dieff. *New Zealand*, vol. 2, p. 231.
1849. *Struthiolaria papulosa* Martyn: Reeve, *Conch. Icon.*, vol. 6, pl. 1.
1849. *Struthiolaria straminea* Gmelin: Reeve, *Conch. Icon.*, vol. 6, f. 3.
1857. *Struthiolaria papillaria* Gray, *Guide Moll. Brit. Mus.*, p. 76.
1858. *Struthiolaria papulosa* Martyn: Adams, *Gen. Rec. Moll.*, pl. 27, f. 6, *b*.
1859. *Struthiolaria papulosa* Martyn: Chenu, *Man. Conch.*, vol. 1, p. 263, f. 1649.
1868. *Struthiolaria stramineus* Woodward, *Man. Moll.*, pl. 4, f. 6.
1873. *Struthiolaria gigas* Sowerby: Hutton, *Cat. Mar. Moll. N.Z.*, p. 24.
1873. *Struthiolaria nodulosa* Lamarck: Hutton, *Cat. Mar. Moll. N.Z.*, p. 24.
1873. *Struthiolaria nodulosa* Lamarck: Hutton, *Cat. Tert. Moll. N.Z.*, p. 10.
1873. *Struthiolaria papulosa* Martyn: von Martens, *Crit. List*, p. 25.
1876. *Struthiolaria papulosa* Martyn: Paulucci, *Bull. Soc. Malac. Ital.*, ser. 2, vol. 2, p. 225.
1880. *Struthiolaria papulosa* Martyn: Hutton, *Man. N.Z. Moll.*, p. 67.
1885. *Struthiolaria papulosa* Martyn: Tryon, *Man. Conch.* (1), vol. 7, 133, pl. 12, f. 34.
1885. *Struthiolaria gigas* Sowerby: Tryon, *Man. Conch.* (1), vol. 7, 133, pl. 12, f. 37.
1885. *Struthiolaria sulcata* Jonas: Tryon, *Man. Conch.* (1), vol. 7, 134, pl. 12, f. 38.
1887. *Struthiolaria nodulosa* Lamarck: Fischer, *Man. Conch.*, p. 877, pl. 4, f. 6.
1893. *Struthiolaria papulosa* Martyn: Hutton, *Macleay Mem. Vol.*, p. 60.
1897. *Struthiolaria papulosa* Martyn: Harris, *Cat. Tert. Moll. Brit. Mus.*, i, p. 219.
1904. *Struthiolaria papulosa* Martyn: Cossmann, *Ess. Paléo. Comp.*, vol. 6, p. 104
1913. *Struthiolaria papulosa* Martyn: Suter, *Man. N.Z. Moll.*, p. 274, pl. 40, fig. 1.

Among Recent specimens there is a considerable variation of form and sculpture. In some the spines on the shoulder are large, strong, and sharply pointed, while in others the shoulder bears only small, spaced nodules. The former may be regarded as the typical *papulosa*, while the

latter represent Sowerby's *gigas*. In a card of five Stewart Island specimens in the Dominion Museum, two are typically nodulous; two have the nodules becoming obsolete on the later whorls, with a corresponding rounding of the shoulder; while the fifth has almost regularly convex whorls throughout, with the merest traces of the nodules on the rounded shoulder—it has, in fact, somewhat the appearance of Tryon's figure of *S. sulcata* Jonas.

It does not at present seem advisable to give any of these aberrant forms specific recognition. The one with rounded whorls and obsolete tubercles can, however, be distinguished easily, and it is possible that a separate species is represented.

Localities.—Recent, Castlecliff and Kai Iwi, Wanganui; 1094, Mangatahi River, Hawke's Bay (very strong spirals—Plate 12, fig. 4); 875, Manaia Beach, Taranaki (M. Ongley); 858, below waterfall, Starborough Creek.

The specimens from the last three localities are by no means typical. Those from Manaia and Starborough resemble a tumid form of the nodular variety, and have the nodules very closely placed.

The only shell closely resembling *S. papulosa* from a possibly lower horizon than Pliocene is one from Kanieri. This is Hutton's *S. cincta* var. B of 1873. The specimen has very much the aspect of the Stewart Island shell with rounded whorls, mentioned above, and was thought by Suter to be *S. papulosa*. Another specimen in the Geological Survey collection from the same district (154, Kanieri) has whorls more angled, but also only traces of nodules. Both are fragmentary, and the second has the suggestion of a keel on the body-whorl. So until better specimens are found it does not seem justifiable to extend the range of *S. papulosa* back to the Miocene. Several fossils from Kanieri have Wanganuian affinities, and may be from Pliocene strata in the neighbourhood.

Struthiolaria frazeri Hutton. (Plate 13, figs. 8, 10.)

- 1885. *Struthiolaria frazeri* (Hector MS.): Hutton. *Trans. N.Z. Inst.*, vol. 17, p. 329.
- 1886. *Struthiolaria fraseri* Hector, *Outline N.Z. Geol.*, p. 48, fig. 5, No. 1.
- 1893. *Struthiolaria frazeri* Hutton, *Macleay Mem. Vol.*, p. 61.
- 1897. *Struthiolaria frazeri* Hutton: Harris, *Cat. Tert. Moll. Brit. Mus.*, i, p. 220, pl. vi, figs. 10, *a*, *b*.
- 1910. *Struthiolaria frazeri* Park, *Geol. N.Z.*, p. 162, fig. 81.
- 1913. *Struthiolaria frazeri* Hutton: Speight, *Rec. Cant. Mus.*, No. 2, pt. 1, p. 31.
- 1921. *Struthiolaria frazeri* Hutton: Suter, *N.Z. Geol. Surv. Pal. Bull. No. 8*, p. 19.

In revising Hutton's types, Suter did not find that of *S. frazeri*, which Hutton described while he was in Christchurch. Professor Speight informed me in a private communication that it is not in Canterbury Museum, and thinks that the fine specimen in the Geological Survey collection at the Dominion Museum is probably the original type. Consequently this shell becomes the type of the species.

Most of the specimens, including the type, have small blunt tubercles on the shoulder, but others have only the strong, regular, smooth, spiral ribs; of the former variety Harris's figure is an excellent representation, while Hector's figure is equally characteristic of the latter.

As regards the localities, several obscure names have been given, so that it may be well to list and explain them here: Hutton (1885), Kikiwheru Creek; Hutton (1886), Matapiro (found also in the Pareora system);

Hutton (1893), Matapiro: Harris (1897), McLean's station, Napier; Hutton (MS.) (1904), Ngaruroro Station and Motunau; Park (1910), McLean's station, Napier; Speight (1913), Motunau; Suter (1921), Shrimpton's, Ngaruroro River; Marshall and Murdoch (1920), Nukumaru, Wanganui district.

Most of these refer to the same place. "Shrimpton's" was a station on the Kikowhero Creek, which is a tributary coming in on the north side of the Ngaruroro River, and forming the eastern boundary of the Matapiro Plain. McLean's was a station on the south side of the Ngaruroro River, opposite Shrimpton's. (*Rep. Geol. Explor.*, x, xii, xviii.)

The statement that this species is "found also in the Pareora system" refers, no doubt, to the specimen recorded from Motunau. I have not seen the specimen, so cannot confirm the identification. In any case, the Motunau beds are now recognized as belonging to a much higher horizon than the Pareora. The Blue Clays of the Ngaruroro River, the type locality of this fossil, are equivalent to the Nukumaru stage of the Wanganuian, so the record of *S. frazeri* by Marshall and Murdoch from Nukumaru is most interesting. Unfortunately, the specimen was broken to pieces in transmission from Mr. Suter.

The identification of *S. frazeri* in the Wangaloa beds (Marshall, 1917, p. 451) is surely a mistake.

Four excellent specimens were collected by Dr. Uttley and the writer in a sandy pocket of the clays not far below the Scinde Island limestone at Maraekakaho, Ngaruroro River.

Struthiolaria sp. Zittel.

1864. *Struthiolaria* sp. Zittel, *Reise der "Novara,"* Geol. Theil, 1 Band, 2 Abt., *Palaontologie von Neu Seeland*, p. 35, pl. xv, fig. 3.

In the Geological Survey collection from locality 126, Awatere Valley, are fragments which should probably be placed here; but their condition is no better than Zittel's material, so no good purpose would be served by attempting specific description.

A similar shell, but with sharper spines, occurs at Kaawa Creek, but here again only fragments are available. In both cases there is a strong callus on the inner lip, recalling that of *S. spinosa*, but the spire is flatter than in the Pareora shell, and the keel is weaker.

(*b.*) *Struthiolaria callosa* Group.

Struthiolaria callosa n. sp. (Plate 14, figs. 7, 8, 9.)

Shell large, ovate, with gradate spire, about same height as aperture; whorls five, angled about middle with wide slightly-inclined shoulder, body-whorl bicarinate; sculpture, fine regular spiral threads on upper whorls, becoming obsolete on lower, the shoulder-angle furnished with about 8 distant strong tubercles, lower keel also has tubercles but smaller and more numerous; suture slightly undulating, filled with layer of enamel which towards aperture reaches to tubercles above; aperture inclined, ovate; outer lip reflexed, moderately thickened, wedge-shaped, sinuous, projecting slightly at shoulder but more so at lower keel, bent then in wide shallow sinus to anterior canal; columella concave, bent to right below and ending in rounded beak; inner lip with enormous callus-pad reaching suture above, ending below about middle of base with rounded knob which

is separated from beak by deep rounded lightly-calloused channel; similarly at its junction with outer lip above, pad ends in rounded knob, causing a channel on shoulder.

Holotype in collection of the New Zealand Geological Survey.

Height, 70 mm.; diameter, 50 mm.

Localities.—1037, Hurupi Creek, Palliser Bay, 300 yards above mouth, at base of Tertiary beds (holotype) (also collected by Dr. J. A. Thomson); 1065, grit band, Kururau Road, Piopiotea West Survey District (L. I. Grange).

The following localities have provided fragmentary specimens belonging either to this species or to one closely related: 619, Paparoa Rapids, Wanganui River; 832, below crossing, Mohaka River; 859, Deadman's Creek, Marlborough (Dr. J. A. Thomson); 904, quarter-mile south of saddle, Okaroa Road, Rangi Survey District (Dr. J. Henderson); 1047, 1049, grit band east of mouth of Okahukura Tunnel, Rangi Survey District (L. I. Grange); 1052, 25 chains along road east side of Okahukura saddle, Rangi Survey District (L. I. Grange); Lower Awatere beds, Tachell's Creek, Marlborough (*S. tuberculata* of Suter, *N.Z. Geol. Surv. Pal. Bull. No. 8*, p. 31).

Struthiolaria fortis n. sp. (Plate 14, figs. 1, 2, 3.)

Shell small, ovate, with gradate spire shorter than aperture; whorls 5 remaining, angled about middle with sloping shoulder, body-whorl bicarinate; sculpture, shoulder with few obsolete spiral threads, angle armed with 7 or 8 strong tubercles, and keel with smaller and closer ones, growth-lines very strong, suture undulating and showing layer of enamel getting higher towards aperture; aperture inclined, semilunar, produced into very short canal below; outer lip reflexed, thickened, wedge-shaped in cross-section, bisinuous, more projecting at lower keel than at shoulder-angle; inner lip with enormous pad, not surmounting shoulder, but very thick and with strong projecting ends, forming channel between beak and basal end of pad, and another on shoulder; columella concave, strongly bent to right below.

Holotype in collection of the New Zealand Geological Survey.

Height, 33 mm.; diameter, 24 mm.

Localities.—1035 (holotype), Shelton's Whare traverse, Block XI. Tutamoe Survey District, Raukumara Division (E. O. Macpherson); 1044, Motumati Waterfall, Waingaromia Survey District, Raukumara Division (= *S. calcar* Hutton of Marshall, 1910, *N.Z. Geol. Surv. Bull. No. 9* (n.s.), p. 22).

This species differs from *S. callosa* in its much smaller size, and narrower pad projecting sharply at both ends and forming deeper channels. The columella is also more bent to the right, and the whorls are lower.

Struthiolaria armata n. sp. (Plate 14, fig. 4.)

This species resembles *S. spinifera* just as *S. callosa* resembles *S. spinosa*. It has a high spire with very sloping shoulders and long strong spines on the shoulder-angle, 7 to 8 on the body-whorl and 6 on each of the spire-whorls.

The suture is filled with a layer of callus which ascends to the tubercles above, while the inner-lip pad extends to about half-way between the tubercles and the suture, but does not quite bury the spines. The growth-lines are very strong, but there is no spiral ornamentation.

As only spires of three specimens are available, full specific description cannot be given, but the characteristic and easily identified spire justifies the application of a specific name.

Localities. — Muddy Creek, Tutamoe Survey District, Raukumara (M. Ongley and E. O. Macpherson); 1034, lowest band, Shelton's Whare traverse, Block XI, Tutamoe Survey District.

Struthiolaria obesa Hutton. (Plate 14, figs. 5, 6.)

1885. *Struthiolaria obesa* Hutton, *Trans. N.Z. Inst.*, vol. 17, p. 329.
1887. *Struthiolaria obesa* Hutton, *Proc. Linn. Soc. N.S.W.*, ser. 2, vol. 1, p. 217.
1913. *Struthiolaria (Pelicaria) obesa* Hutton: Speight, *Rec. Cant. Mus.*, No. 2, pt. 1, p. 32.
1915. *Struthiolaria (Pelicaria) obesa* Hutton: Suter, *N.Z. Geol. Sur. Pal. Bull. No. 3*, p. 7, pl. iv, fig. 3.

The aperture of this species is very like that of *S. callosa*. The calloused pad surmounts the shoulder, passes the suture, and adheres to the whorl above. Anteriorly the pad ends in a raised knob separated by a smooth channel from the beak. The columella is only moderately bent, ending in a strong beak, and the outer-lip callus does not form the body-whorl. The shell is consequently not a *Tylospira* (= *Pelicaria*), as Suter thought, but a *Struthiolaria* of the *callosa* group.

The spire-whorls are convex, the body-whorl obsoletely bicarinate, and there are traces of fine spiral striae. As the tendency of the genus seems, in the main, to have been towards a loss of tubercles in the more advanced forms, this species appears to have reached a gerontic stage.

Localities.—Shepherd's Hut, Waipara; Porter River, Trelissick Basin.

These specimens are in the Canterbury Museum, and were kindly lent by Professor Speight.

? Awamoa. A fragmentary specimen in Mr. Finlay's collection. The aperture and callus are broken off, so the identity is not quite certain.

The Porter River specimens are identical in state of preservation and appearance with the Shepherd's Hut ones; even the scattered grains of sand adhering in both cases are similar, suggesting that they are from the same locality—*i.e.*, Waipara.

(c.) *Struthiolaria vermis* Group.

Struthiolaria sp.

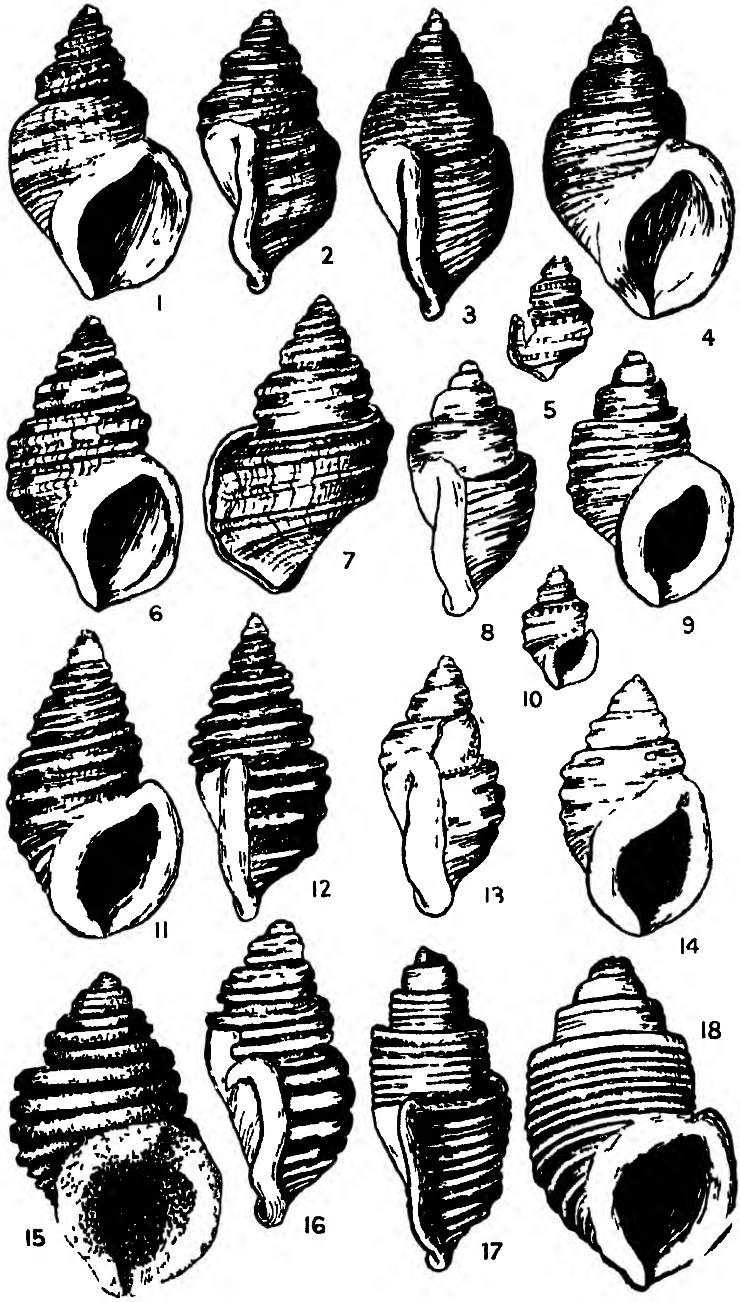
A single distorted shell from the Tawhiti beds, probably of Upper Miocene age, is of great interest, for it marks the first known appearance of this group in the Tertiary sequence. The ornamentation consists of 2 and later 3 spiral cinguli on the spire-whorls, and so resembles that of *S. tricarinata*. The base has but 3 or 4 strong cords, a condition found only in the Lower Pliocene forms *S. canaliculata*, *S. acuminata*, and *S. monilifera*.

Locality. —1091, base of sandstone, three miles south-east of Trig. S. 45, north border Waiapu Survey District (Dr. J. Henderson).

Struthiolaria canaliculata Zittel. (Plate 15, figs. 15, 16.)

1864. *Struthiolaria canaliculata* Zittel, *Reise der "Novara,"* 1 Bd., 2 Abt., p. 34, pl. xv, figs. 1, *a*, *b*.
1873. *Struthiolaria sulcata* Hutton, *Cat. Tert. Moll.*, p. 10 (not of Jonas, 1829).
1887. *Struthiolaria sulcata* Hutton, *Proc. Linn. Soc. N.S.W.*, ser. 2, vol. 1, p. 217.
1914. *Struthiolaria canaliculata* Zittel: Suter, *N.Z. Geol. Surv. Pal. Bull. No. 2*, p. 17, pl. xvii, figs. 8, *a*, *b*.

Suter quotes, in the synonymy, Hector's figure of 1886. This, from its elongated outline, must have been drawn from a specimen of *S. acuminata*



FIGS. 1, 2.—*Struthiolaria vermis* (Mart.). Recent.
FIGS. 3, 4.—*Struthiolaria convexa* n. sp. Type.
FIGS. 5, 10.—*Struthiolaria parva* Sut. Type.
FIGS. 6, 7.—*Struthiolaria tricarinata* Less Recent.
FIGS. 8, 9.—*Struthiolaria fossa* n. sp. Type.
FIGS. 11, 12.—*Struthiolaria acuminata* n sp. Type.
FIGS. 13, 14 -*Struthiolaria media* n sp. Type.
FIGS. 15, 16. — *Struthiolaria canalicalata* Zitt. (Fig. 15 after Zitt.)
FIGS. 17, 18 - -*Struthiolaria zelandiae* Marsh. & Murd Waipipi

n. sp., which Hutton did not separate from Zittel's *S. canaliculata*. The latter is easily distinguished by its robust form, strong square spiral cords, and deep flat interstices. The suture is situated in a wide canal, and in some cases a fourth rib appears low down on the penultimate whorl.

Locality.—Zittel gives as the locality "Awatere Valley," which is somewhat indefinite, but Dr. J. A. Thomson collected two typical specimens from 858, "below waterfall, Starborough Creek, lower end Awatere Valley." This is probably the type locality, and the species must be considered as a Pliocene one.

Struthiolaria zelandiae Marshall and Murdoch, 1920. (Plate 15, figs. 17, 18.)

1920. *Struthiolaria zelandiae* Marshall and Murdoch, *Trans. N.Z. Inst.*, vol. 52, p. 130. pl. vii, figs. 11, 11*a*.

In this species an advance from such types as *S. canaliculata* and *S. acuminata* is marked by the appearance of a strong secondary spiral cord in each of the interstices between the 4 primary spirals. There is also a tendency for the second and third primaries to divide, and when this happens each part is often weaker than he secondaries. Thus the 4 spirals of *S. canaliculata* may be represented by 7, 8, or 9 spirals in *S. zelandiae*. The holotype figured by Marshall and Murdoch belongs to the last kind. As most of the specimens are flattened by pressure, the figures of Marshall and Murdoch make this shell appear too broad; a side as well as a front view is therefore given on Plate 15, figs. 17, 18. The deep canaliculate suture shows that this species has reached a gerontic stage.

Localities.—Waipipi Beach, west of Wairoa Stream, Waverley (type); 876, mouth of Waihi Stream, Hawera (M. Ongley) (first form = *S. canaliculata* of Suter, *N.Z. Geol. Surv. Pal. Bull. No. 8*, p. 25); mouth of Waingongoro River, Taranaki (Dr. G. H. Uttley and J. Marwick).

Struthiolaria acuminata n. sp. (Plate 15, figs. 11, 12.)

1886. *Struthiolaria sulcata* Hector, *Outline of N.Z. Geol.*, p. 50, fig. 6, No. 7 (not of Hutton, 1873).

1914. *Struthiolaria sulcata* Hutton: Chapman, *Australasian Fossils*, p. 200, fig. 103, F (not of Hutton or Jonas).

Shell somewhat small, ovate, with acute turreted spire longer than aperture. Whorls 6, gradually increasing; sculpture, whorls immediately below apex convex and with spiral cords, third whorl bicarinate, keels being marked by 2 strong cinguli, on fourth and fifth whorls these become much stronger, raised and rounded, angle of shoulder has now developed strong raised band so whorls are tricarinate, interstices being rounded and a little wider than spiral ribs; on body-whorl are 5 strong raised rounded cinguli, the lowest near fourth and slightly weaker than the others; on base are 4 strong spiral threads with wide interstices; the whole surface spiralled with fine obsolete threads, crossed by sinuous growth-lines; suture situated in channel formed by strong spirals, whorl being slightly depressed between top spiral and suture; aperture ovate, channelled above and produced below into very short canal; outer lip reflexed, thickened, edge rounded, sinuosity very shallow; columella concave, ending in truncated beak, bent to right, inner lip with moderate regular callus equal in width to that of outer lip, and not ascending on body-whorl above outer llip.

Holotype in collection of the New Zealand Geological Survey.

Height, 43 mm.; diameter, 26 mm.

Localities. 1040, greensand below Wairarapa limestone, at Twaite's cutting, five miles south of Martinborough (holotype); coast half-mile east of Ruamahanga River mouth, Palliser Bay (Dr. J. A. Thomson).

Remarks.—This shell is intermediate in appearance between *S. canaliculata* and *S. tricarinata*; it is higher in the spire than either, more slender than the former, with rounded ribs and wider interstices; it may be distinguished from the latter by its 5 regular, strong, rounded ribs on body-whorl, and only 4 cords on the base.

Hutton collected this species from "east coast, Wellington," but did not separate it from *S. canaliculata*. The figure so labelled in Hector's *Outline* must have been drawn from a specimen of *S. acuminata*, for it shows the high spire.

Struthiolaria monilifera Suter. (Plate 13, fig. 7.)

1873. *Struthiolaria cingulata* Zittel var. B Hutton, *Cat. Tert. Moll.*, p. 11.
1886. *Struthiolaria cingulata* Hector, *Outline of N.Z. Geol.*, p. 51, fig. 9, No. 17 (not of Zittel).
1914. *Struthiolaria cingulata* subsp. *monilifera* Suter, *N.Z. Geol. Surv. Pal. Bull. No. 2*, p. 18, pl. 1, fig. 10.

As has been stated above (p. 179), *S. cingulata* belongs to the *S. papulosa* group, but *S. monilifera* has the characteristic outline, aperture, and typical arrangement of cinguli shown by the *S. vermis* group; it must therefore be granted at least specific distinction from *S. cingulata*. These features, together with the strong spirals on the base, show that the closest relationship is to *S. acuminata*. The mistake of coupling *S. monilifera* with *S. cingulata* was caused by Hutton's wrongful identification of a shell from Patea as the latter species. This shell, also an undoubted member of the *vermis* group, was Hutton's plesiotype of *S. cingulata*, and was figured by Suter (1914). It is here described and named as a new species, *S. rugosa* (see p. 189).

No good specimens of *S. cingulata* were available for the figure of this species in Hector's *Outline*, so one was drawn from Hutton's variety B—*i.e.*, *S. monilifera*.

Struthiolaria tricarinata Lesson. (Plate 15, figs. 6, 7.)

1830. *Struthiolaria tricarinata* Lesson, *Ann. Sci. Nat.*, ser. 2, vol. 16, p. 256.
1880. *Struthiolaria vermis tricarinata* Lesson: Hutton, *Man. N.Z. Moll.*, p. 68.
1913. *Struthiolaria vermis tricarinata* Lesson: Suter, *Man. N.Z. Moll.*, p. 276.

The strong spiral cinguli of this shell show that it is a more primitive form than *S. vermis*, and on that account it is deemed advisable to grant it full specific recognition. No doubt intermediate forms occur, but the extremes are well separated.

On the base are about 7 fine spiral lines, showing an advance from *S. acuminata*, which has only 4 strong cords.

The specimen here figured is in the Dominion Museum collection, and comes from Farewell Spit, Nelson.

Fossil Locality.- Languard Bluff, Wanganui (R. Murdoch).

Suter (1913) wrongly quotes in his synonymy of *S. tricarinata* Gray's record of *S. scutulata* Martyn, in Dieffenbach's *New Zealand*. Gray merely lists *S. scutulata* as recorded from New Zealand by Martyn, the author of the species. The mistake originated in Martyn's statement that *B. scutulatum* was a New Zealand shell. In the same synonymy (Suter, 1913) Hutton's use of *S. scutulata* as of Deshayes is given as being intended for

S. tricarinata. This also appears to be a mistake, for in his *Manual* (1880, p. 219) Hutton used *S. australis* Gmel. as the equivalent of his *S. scutulata* Desh., and listed *S. tricarinata* as a different species

Struthiolaria parva Suter. (Plate 15, figs. 5, 10.)

1915. *Struthiolaria parva* (Hutton MS.): Suter, *N.Z. Geol. Surv. Pal. Bull. No. 3*, p. 7, pl. iv, fig. 4.

As the locality of the holotype is unknown, it is a pity that this shell was described. In appearance it resembles young *S. vermis*, particularly those forms which have the tubercles well developed. If the specimen represents the normal adult it is a valid species, closely related to *S. tricarinata* and *S. vermis*.

Struthiolaria vermis (Martyn). (Plate 15, figs. 1, 2.)

1786. *Buccinum vermis* Martyn, *Univ. Conch.*, vol. 2, fig. 53.
1790. *Murex australis* Gmelin: Linn., *Syst. Nat.*, ed. 13, 1, 3542.
1822. *Struthiolaria crenulata* Lamarck, *Anim. s. Vert.*, vol. 7, p. 148.
1835. *Struthiolaria crenulata* Lamarck: Q. & G., "*Astrolabe*," vol. 2, p. 430, pl. 31, figs. 7 9.
1835. *Struthiolaria crenulata* Lamarck: Gray in Yate's *New Zealand*, p. 308.
1842. *Struthiolaria inermis* Sowerby, *Thes. Conch.*, vol. 1, p. 23, pl. 5, figs. 12, 13, 19.
1849. *Struthiolaria australis* Reeve, *Conch. Icon.*, vol. 6, fig. 1.
1858. *Struthiolaria vermis* Martyn: Adams, *Gen. Rec. Moll.*, pl. 27, fig. 6.
1859. *Struthiolaria vermis* Martyn: Chenu, *Man. Conch.*, vol. 1, p. 263, fig. 1653.
1873. *Struthiolaria scutulata* Desh.: Hutton, *Cat. Mar. Moll. N.Z.*, p. 24 (wrongly attributed to Desh., not of Martyn).
1873. *Struthiolaria vermis* Martyn: Hutton, *Cat. Mar. Moll. N.Z.*, p. 24.
1873. *Struthiolaria vermis* Martyn: Hutton, *Cat. Tert. Moll. N.Z.*, p. 10.
1873. *Struthiolaria australis* Gmelin: von Martens, *Crit. List*, p. 26.
1876. *Struthiolaria vermis* Martyn: Paulucci, *Bull. Soc. Malac. Ital.*, ser. 2, vol. 2, p. 229.
1880. *Struthiolaria australis* Gmelin: Hutton, *Man. N.Z. Moll.*, p. 68.
1880. *Struthiolaria inermis* Sowerby: Hutton, *Man. N.Z. Moll.*, p. 68.
1885. *Struthiolaria vermis* Martyn: Tryon, *Man. Conch.*, ser. 1, vol. 7, p. 133, pl. 12, figs. 35, 36.
1893. *Struthiolaria vermis* Martyn: Hutton, *Macleay Mem Vol.*, p. 61.
1894. *Struthiolaria vermis* Martyn: Harris, *Cat. Tert. Moll. Brit. Mus.* (Aust.), p. 219.
1904. *Struthiolaria vermis* Martyn: Cossman, *Ess. Paleo. Comp.*, vol. 6, pl. 8, fig. 2.
1913. *Struthiolaria vermis* Martyn: Suter, *Man. N.Z. Moll.*, p. 276, pl. 40, fig. 2.

There is a considerable amount of variation in living specimens of this shell, and when one goes back to the Pliocene the variations are still more considerable. All the Recent examples appear to have the same very fine spiral striae of somewhat irregular strength. The prominence of the spiral cinguli, and the presence on them of tubercles, are the most variable features. The arrangement of these cinguli corresponds to that of *S. canaliculata*, and, indeed, to that of the whole group.

Localities.—Castlecliff; ? Petane.

Struthiolaria media n. sp. (Plate 15, figs. 13, 14.)

Shell somewhat small, ovate, with turreted spire about equal in height to aperture; whorls 6, regularly increasing; sculpture, the first two whorls convex with from 6 to 8 spiral threads, with slightly wider interstices, third whorl with about 12 spiral threads, two very weak cinguli beginning to appear, fourth and fifth whorls with 2 strong cinguli, the

whole surface with about 12 spiral threads some of which are more prominent than others, body-whorl with 4 strong rounded spiral cinguli, and a fifth rudimentary on base, which has 6 stronger threads and 4 or 5 weak ones, the fine spirals of spire continue on body-whorl, but in interstices of cinguli there is generally one more prominent than others; suture bounded below by narrow flat surface; aperture ovate, channelled above, produced below into very short canal; outer lip reflexed, thickened, edge rounded, sinuosity very shallow. Columella concave, ending in truncated beak bent to right, inner lip with regular callus, about equal in width to outer lip.

Holotype in collection of the New Zealand Geological Survey.

Height, 36 mm.; diameter, 23 mm.

Localities.—81, Castle Point, east Wellington; 1040, Twaite's Cutting, Martinborough.

Remarks.—This species differs from *S. acuminata* in its shorter spire and weaker cinguli; from *S. parva* in its greater size, wide cinguli, and many more spirals on base. The nearest relationship is to *S. fossa* and to *S. convexa.* The former has weaker cinguli, flat sides, and canaliculate suture, while the latter may be distinguished by its very much weaker cinguli and convex outline. The systematic position is probably between *S. acuminata* and *S. convexa*, development being along the lines of a weakening of the spiral cinguli and an increase in the number and decrease in strength of spirals on the base.

Struthiolaria convexa n. sp. (Plate 15, figs. 3, 4.)

Shell ovate, plump; spire acute, about same height as aperture; protoconch an elongated bulbous nucleus, at right angles to axis of shell; whorls 6, increasing rather rapidly, convex in outline; sculpture, first three conch-whorls have 11 regular spirals, with interstices of slightly greater width, on fourth whorl a single thread in most of interstices, on fifth and sixth whorls secondary threads rapidly increase in number, generally 1 on each side of and close to primaries, with 1 or more in wide interspaces; suture with a flattened border on first four whorls and in shallow channel on last two; aperture ovate, channelled above, produced below into very short widely-open canal; outer lip reflexed, thickened, edge rounded, sinuosity very shallow; columella concave, ending in beak bent to right; inner lip with fairly regular callus, equal in width to and hardly ascending above junction with outer lip.

Holotype in collection of the New Zealand Geological Survey.

Height, 43 mm.; diameter, 28 mm.

Localities.—1089, blue clays, Okauawa Creek, Ngaruroro River; 184, blue clay west of limestone scarp, Porangahau Creek, Ruataniwha Plain (holotype); 231, McLean's station, south side of Ngaruroro River, Hawke's Bay; blue clays below Napier limestone at many localities in the Ngaruroro and Matapiro Survey Districts, Hawke's Bay.

Remarks.—Distinguished from *S. vermis* by convex outline and more regular sculpture. Many of the larger specimens show a definite grouping of the spiral striae corresponding to the cinguli on other members of the group. The species is closely related to *S. fossa*, but it seems to have diverged along a line of increasing convexity instead of increasing flatness of the whorls. Some of the specimens are difficult to separate from *S. vermis*, but in the latter species the spiral striae are always finer and more irregular.

Struthiolaria fossa n. sp. (Plate 15, figs. 8, 9.)

Shell small, ovate; spire gradate, about equal in height to aperture; whorls 5, but apex broken, early whorls convex, later ones with high shoulder and sides inclined to be flat; sculpture, first three whorls regularly spiralled by 12 fine cords with equal interstices, on penultimate whorl these become narrow ridges with wide interstices, there are also 2 obscure but wide cinguli, the raised shoulder has now 3 fine spiral threads; body-whorl with 5 spirals on shoulder, and 21 narrow spiral ridges with wide interstices below, the 6 on base being slightly stronger; 5 obscure cinguli with equal interspaces; suture in deep channel, 2 mm. wide; aperture ovate, channelled above, produced below into very short open canal; outer lip thickened, reflexed, only slightly sinuous, edge rounded, columella concave, ending in beak bent forwards and to right; inner lip regularly calloused, equal in width to outer lip, not ascending on body-whorl.

Holotype in collection of the New Zealand Geological Survey.

Height, 36 mm.; diameter, 25 mm.

Locality.—191, Shrimpton's, Kikowhero Creek, Ngaruroro River, Hawke's Bay.

Remarks.—This species is characterized by the deeply excavated channel round the shoulder of the whorls. In ornamentation it resembles some varieties of *S. vermis*, but may be distinguished by the much stronger and more regular spiral ridges, as well as by the even, though weak, cinguli. It further differs from *S. parva* in having weaker cinguli and flatter sides.

A close connection exists between *S. fossa* and *S. convexa;* both occur in the same district and in the same formation. The two shells are easily separated, however, by means of the canaliculate suture and flat sides of the former. These features show that the species is not only more advanced than *S. convexa*, but is also a phylogerontic development.

Struthiolaria rugosa n. sp. (Plate 13, fig. 2.)

1914. *Struthiolaria cingulata* Zittel: Suter, *N.Z. Geol. Surv. Pal. Bull. No. 2*, pl. 1, fig. 9 (not of Zittel).

Shell ovate, spire about same height as aperture; whorls 6, convex; sculpture, spire-whorls with 5–6 strong cords with narrow interstices, lowest cord being wide and having secondary spirals on it and on wide interspace below it, body-whorl with 15 equal cords, with interstices of almost same width and generally containing fine secondary spiral, growth-lines very strong over whole shell, giving spiral cords a moniliform appearance; aperture ovate, channelled above, with very short wide canal below; outer lip thickened, reflexed, bisinuous; inner lip with strong regular callus equal in width to outer lip; columella concave, strongly bent to right below.

Holotype in collection of the New Zealand Geological Survey.

Height, 40 mm.; diameter, 27 mm.

Locality.—Patea.

Remarks.—As stated on page 179, this shell was Hutton's plesiotype of *S. cingulata* Zittel. This mistake arose from Zittel's figure representing a specimen with unusually convex whorls; but the characteristics features, obsolete bicarination of the body-whorl, and the disposition of the inner lip-callus show that *S. cingulata* belongs to the *papulosa* group, whereas there can be no doubt that this specimen falls under the *vermis* group. In outline it is very near *S. convexa*, but is easily distinguished by the strong spiral cords, which are rendered moniliform by the prominent growth-lines.

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Palaeontological Notes on some Pliocene Mollusca from Hawke's Bay.

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[*Read, by permission of the Director of the N.Z. Geological Survey, before the Wellington Philosophical Society, 9th August, 1922; received by Editor, 31st December, 1922; issued separately, 6th June, 1924.*]

Plates 16, 17.

THE following notes formed part of a paper on the geology of the Ngaruroro-Waipawa district, read before the Wellington Philosophical Society by Dr. G. H. Uttley and the writer. It is hoped that the main part of the paper will be published next year.

All of the fossils mentioned below came from the clays and sands known as the Petane clays, which underlie the Petane limestone and overlie the Te Aute limestone, and which are beautifully exposed along the Ngaruroro River, especially around Maraekakaho.

The percentage of Recent Mollusca was found to be 63; but it would be incorrect to use this as a ground for correlation with faunas worked out by the late Mr. Suter, for many species regarded by him as Recent have been separated as distinct. The presence of the large *Lutraria solida* Hutton and *Melina zealandica* Suter, as well as the low percentage of Recent forms, shows that the beds are older than the Castlecliffian (Marshall and Murdoch, 1920, p. 120), while many Upper Wanganuian species, such as *Drillia buchanani* (Hutton), *Drillia wanganuiensis* (Hutton), *Bathytoma nodilirata* (Murdoch and Suter), *Philobyra trigonopsis* (Hutton), *Struthiolaria frazeri* Hutton, &c., forbid correlation with the Waipipian. Thus the Nukumaruian or Middle Wanganuian is indicated as the age of the Petane clays.

Anomia undata Hutton. (Plate 16, figs. 9, 13.)

1885. *Anomia undata* Hutton, *Trans. N.Z. Inst.*, vol. 17, p. 324.
1893. *Anomia undata* Hutton, *Macleay Mem. Vol.*, p. 90, pl. 9, fig. 95.
1915. *Anomia undata* Hutton: Suter, *N.Z. Geol. Surv. Pal. Bull. No. 3*, p. 48

This species was founded on "undulations . . . more or less parallel" shown by the type and other specimens. It is well known that the animals of this genus reflect the sculpture of the shell to which they are attached, so the undulations are useless from a classificatory point of view. Those of the holotype are a copy of the coarse concentric sculpture of a pelecypod, perhaps *Chione subsulcata* Suter. *Anomia undata*, nevertheless, should be retained, for it has other quite distinctive features. Mr. W. R. B. Oliver, who has studied the Recent forms, found that *A. huttoni* could not be separated from *A. trigonopsis*; therefore it will be sufficient to differentiate *undata* from the latter species. The holotype is a young shell, and naturally does not show the distinguishing characters as clearly as the adult. That a very young *A. undata* agrees with the adult *A. trigonopsis* merely suggests that the former is an offshoot from the latter. In size *A. undata* far surpasses *A. trigonopsis*, the average adult being 80–90 mm. in diameter, the shape where growth has been free is circular to slightly oval, and the almost smooth surface is traversed by faint growth-lines and a few irregular concentric striae. The full-grown *A. trigonopsis* is generally under 50 mm. in diameter, and has often radial ribs, though this feature is not constant; the majority of large shells seen are inclined to be of irregular shape. The most reliable way to

identify the species is by means of the muscular scars. This again is an extremely variable character, but the variations do not conceal the fact that there are two quite distinct forms. The left valve of *Anomia* has three muscular scars on the central disc; the uppermost, and the anterior or middle one, are byssal adductors, while the lowest or posterior is the adductor of the valves.

In the young *A. undata* the arrangement of these scars is much the same as that of *A. trigonopsis*—*i.e.*, triangular, the uppermost being much larger than either of the others. In the adult *A. undata* the three impressions are arranged almost in a vertical line, and are crowded together. An elongated *A. trigonopsis*, such as the neotype figured by Suter (1915), often shows a somewhat similar arrangement, but the lower byssal adductor is still paired with the valve-adductor, and both are separated from the upper byssal adductor (see Plate 16, fig. 10). In fully-grown *A. undata* the valve-adductor is generally the largest; this is never so in the other species.

Suter's identifications, being based on the undulations, are unreliable; indeed, the true *A. undata* was generally classed by him as *A. huttoni*, which according to his usage comprised the smooth, circular shells.

The species does not appear to have existed in the Miocene; it is particularly common in the Petane clays at Maraekakaho, also at Nukumaru, while there is a Recent example in the Dominion Museum from an unknown locality.

Lima mestayerae n. sp. (Plate 16, figs. 11, 12.)

Shell small, inequilateral; beaks elevated, distant, incurved, sharp, anterior end fairly straight and oblique above, rounded below; posterior end convex, flattened above; sculpture of 22 strong rounded radial ribs, with irregular scales and equal interstices in which are close regular scaly concentric ridges, which do not surmount ribs, submargin with about 8 somewhat irregular narrow ribs and strong growth-lines, posterior ear with 4 narrow ribs, ears small and inconspicuous; hinge-line with a well-marked tubercle on each side; ligamental area broadly triangular, high, with narrow concave triangular resilifer traversing middle; margins dentate.

Holotype in collection of the New Zealand Geological Survey.

Height, 16 mm.; length, 14 mm.

Locality.—1096, clays below limestone, Esk Bridge, Petane.

Remarks.—Distinguished from *L. lima* by small size and greater number of ribs, 22 instead of 18. Compared with a young *L. lima* of the same size, the ears of *L. mestayerae* are much smaller, the shell is narrower and consequently the ribs also, while the ligamental area is a great deal higher.. I am indebted to Miss Mestayer for the loan of Recent material for comparison.

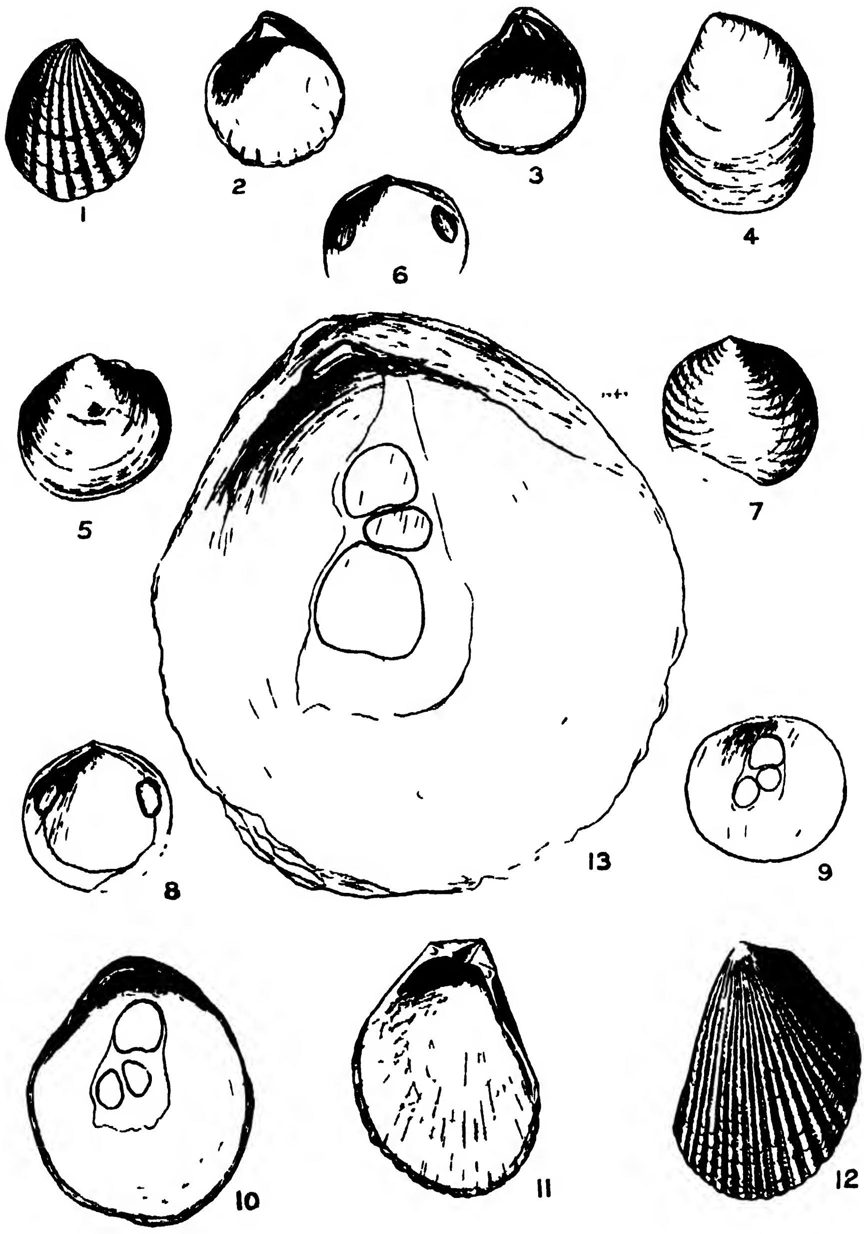
Venericardia (Pleuromeris) marshalli n. sp. (Plate 16, figs. 1, 2.)

1906. *Venericardia corbis* Philippi: Suter, *Trans. N.Z. Inst.*, vol. 38, p. 317 (not of Philippi).

1913. *Venericardia corbis* Philippi: Suter, *Man. N.Z. Moll.*, p. 908, pl. 53, fig. 3 (not of Philippi).

1915. *Venericardia unidentata* (Basterot): Iredale, *Trans. N.Z. Inst.*, vol. 47, p. 487 (not of Basterot).

The identification of this New Zealand shell with *V. corbis*, a Pliocene and Recent species of the Mediterranean, was made by Dr. W. H. Dall, and was accepted by Suter (1906, p. 318). Such a distribution is in itself suspicious; and as, by good fortune, the Dominion Museum has a copy of Philippi's *Enumeratio Molluscorum Siciliae*, in which *V. corbis* is described,



Figs. 1, 2.—*Venericardia marshalli* n. sp.: holotype. × 4.
Figs. 3, 4.—*Venericardia minima* n. sp.: holotype (fig. 3). × 12.
Fig. 5.—*Lucinida dispar* (Hutton): holotype. × 1.
Figs. 6, 7, 8.—*Myllita finlayi* n. sp.: holotype (fig. 8). × 4.
Fig. 9.—*Anomia undata* Hutton: interior of holotype. × 1.
Fig. 10.—*Anomia trigonopsis* Hutton: specimen from Target Gully. × 1.
Figs. 11, 12.—*Lima mestayerae* n. sp.: holotype. × 1.
Fig. 13.—*Anomia undata* Hutton (adult): Maraekakaho. × 1.

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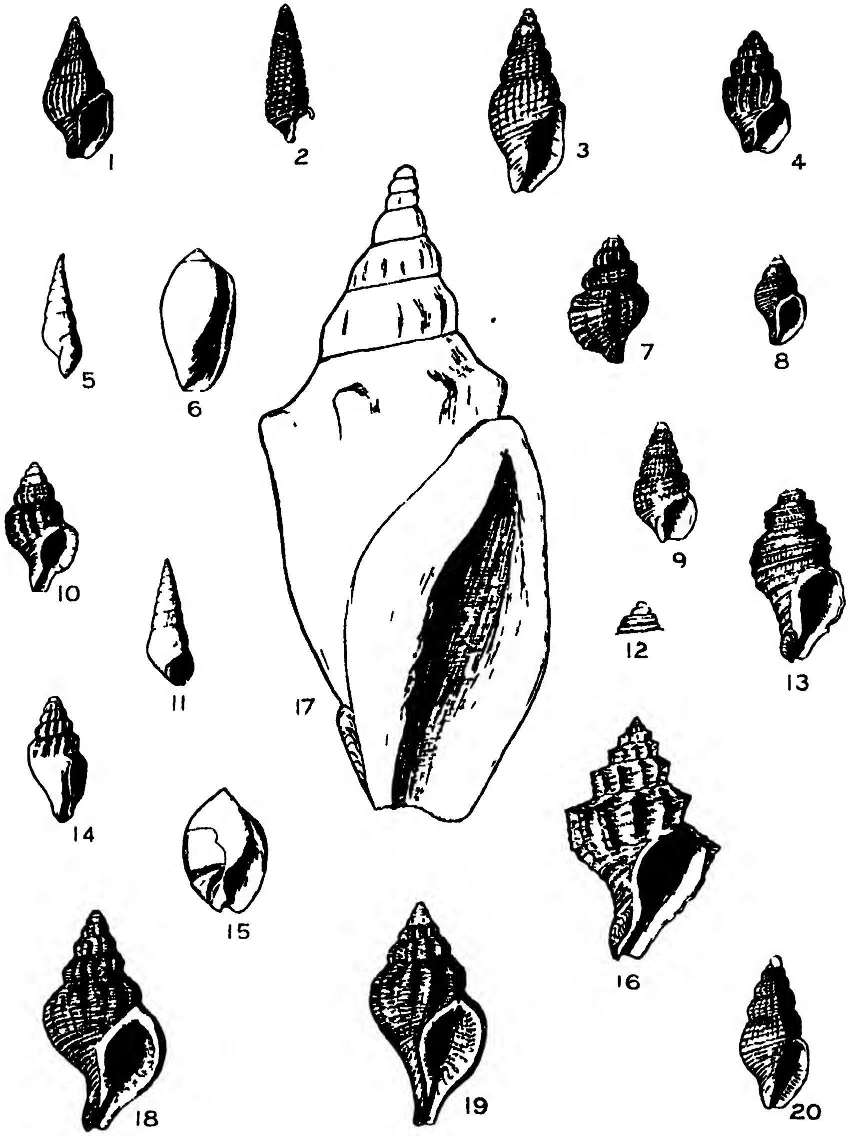

FIG. 1.—*Anachis speighti* n. sp.: holotype. × 2.
FIG. 2.—*Ataxocerithium suteri* n. sp.: holotype. × 1.
FIG. 3.—*Anachis pisaniopsis* (Hutton): holotype. × 2.
FIG. 4.—*Cominella hamiltoni* (Hutton): Maraekakaho. × 1.
FIGS. 5, 11.—*Eulima christyi* n. sp.: holotype. × 1.
FIG. 6.—*Marginella brevespira* n. sp.: holotype. × 2.
FIGS. 7, 10.—*Xymene oliveri* n. sp.: holotype. × 2.
FIG. 8.—*Xymene drewi* (Hutton): lectotype. × 1.
FIG. 9.—*Ataxocerithium tricingulatum* n. sp.: holotype. × 2.
FIGS. 12, 13.—*Trophon murdochi* n. sp.: holotype. × 1.
FIG. 14.—*Mangilia morgani* n. sp.: holotype. × 1.
FIG. 15.—*Ancilla opima* n. sp.: holotype. × 1.
FIG. 16.—*Aethocola taitae* n. sp.: holotype. × 1.
FIG. 17.—*Alcithoe lutea* n. sp.: holotype. × 1.
FIG. 18.—*Verconella dubia* n. sp.: holotype. × 1.
FIG. 19.—*Verconella thomsoni* n. sp.: holotype. × 1.
FIG. 20.—*Anachis cancellaria* (Hutton): holotype. × 2.

a comparison could be made with the original figures and description. The figures show a shell without radial ribs. The short description reads, "striis transversis densis, undulatis, sulcis longtudinalibus obsoletis," while a fuller description below is, "transversim eleganter striata, et sulcis longitudinalibus distantibus parum profundis (interdum obsoletis) decussata." New Zealand specimens, when well preserved, have 11 12 strong somewhat nodular ribs, and so should be separated. There are also differences in shape.

As regards *V. unidentata*, Suter probably quoted this in his synonymy from information supplied by Dall, no date of publication being given in either case. Iredale accepted the synonymy, but pointed out the priority of *unidentata;* he does not appear to have compared New Zealand with European specimens. Cossmann and Peyrot (1912, p. 81) state that the two European species should be kept apart, for in *corbis* the concentric and in *unindentata* the radial ornamentation predominates. These radials are 20–22 in number, so it is surprising that the New Zealand shell with only half as many ribs should have been placed in the same species.

Types of *V. marshalli* (right valve) in the collection of the New Zealand Geological Survey.

Height, 5 mm.; length, 4·5 mm.

Locality.– Stewart Island (Recent). Kindly presented by the late Mr. R. Murdoch.

Subgenerically, this shell should go with *V. lutea* and *V. bollonsi* under *Pleuromeris*, and should not have been under *Miodontiscus* as classed by Suter.

Venericardia (Miodontiscus) minima n. sp. (Plate 16, figs. 3, 4.)

Shell minute, obliquely subtriangular, inequilateral; beaks extremely prominent, median, strongly curved; dorsal margin arched, descending rapidly; basal margin fairly regularly rounded, slightly flattened posteriorly; anterior end projecting, slightly longer than the posterior, convex below but deeply excavated under beaks, lunule not circumscribed, no escutcheon; hinge moderately strong; right valve with anterior and posterior cardinals obsolete, median strong, triangular, oblique, depressed in middle, there is a weak anterior lateral; left valve with two strong cardinals, anterior short, perpendicular, posterior long, curved, oblique; sculpture of obsolete narrow concentric folds, no radials; inner margins crenate.

Holotype (right valve) in collection of the New Zealand Geological Survey.

Height, 1·6 mm.; length, 1·5 mm.

Locality.—1098, blue clays, cutting in main road, Maraekakaho.

Remarks.—According to Dall's description (1903, p. 1409), *Miodontiscus* has the posterior right cardinal absent. In *V. minima* this tooth, though weak, is certainly present. The other characters agree well with this subgenus.

Lucinida dispar (Hutton). (Plate 16, fig. 5.)

1873. *Cyclina dispar* Hutton, *Cat. Tert. Moll.*, p. 22.
1914. *Dosinia subrosea* (Gray): Suter, *N.Z. Geol. Surv. Pal. Bull. No. 2.* p.[1] (not of Gray).
1919. *Lucinida levifoliata* Marshall and Murdoch, *Trans. N.Z. Inst.*, vol. 51. p. 257, pl. 20, figs. 1, 2, 3, 4.

The type (and only) specimen is embedded in a hard matrix, so that the interior cannot be seen; but the exterior of the shell is of such

characteristic shape, with its peculiar expansion in front of the small deep lunule, that there can be no doubt that it is a *Lucinida*. Hutton classified the specimen under *Cyclina* because he mistook the anterior expansion for the lunule, and saw no line circumscribing it, while Suter's identification of it as *Dosinia subrosea* must have been based on a very perfunctory examination. The sculpture consists of fairly regular, spaced, low, concentric lamellae, more irregular distally, thus agreeing well with that of *L. levifoliata*.

Type locality, Hautapu Falls, Upper Rangitikei.

Myllita finlayi n. sp. (Plate 16, figs. 6, 7, 8.)

Shell very small, thin, circular in outline, little inflated; beaks median, inconspicuous; sculpture of very fine curved divaricate ribs, about 4 per millimetre, with their dorsal edges raised and somewhat roughened by irregularly-placed weak concentric growth-lines; hinge—right valve with a bifurcate cardinal under umbo and several minute tubercles posterior to it, double anterior and posterior lateral lamellae, anterior pair slightly stronger, left valve with one cardinal tooth and single anterior and posterior lamellae; muscular impressions subequal, raised; pallial line entire; interior faintly radially striate; margins smooth.

Holotype (right valve) in collection of the New Zealand Geological Survey.

Height, 5 mm.; length, 5 mm.; thickness (one valve), 1·25 mm.

Locality.—1102, sandy beds in blue clays below limestone, Maraekakaho Creek, three miles above mouth.

Remarks.—The generic location under *Myllita* is only provisional. The outline and ribbing are not the same as in that genus, but the whole group will be revised later. A closely related, unnamed species occurs at Castlecliff.

Cerithidea perplexa (Marshall and Murdoch).

1919. *Ataxocerithium perplexum* Marshall and Murdoch, *Trans. N.Z. Inst.*, vol. 51, p. 254, pl. 20, figs. 5, 6.

This shell is very closely related to the Recent *Cerithidea bicarinata* (Gray); indeed, it may not be worth specific recognition, as in the Recent species much of the surface is normally eroded, so all the details of sculpture cannot be made out. The two basal keels of *C. bicarinata* are represented in *C. perplexa*, as may be seen in Marshall and Murdoch's figure, but even in the best-preserved specimens they are obsolete. The whorls of the fossil are inclined to be flatter and the size somewhat larger than the Recent species, so perhaps it would be as well to retain both names. The generic position is under *Cerithidea* rather than *Ataxocerithium*, for the canal is very short and straight.

Ataxocerithium tricingulatum n. sp. (Plate 17, fig. 9.)

Shell small, turreted; spire twice as high as aperture, outlines straight; whorls 6, flat-sided, increasing regularly, body-whorl occupying half height of shell, convex, base contracted to short neck, protoconch broken off; sculpture of 3 strong equidistant spiral cords, crossed by 20 or more equally strong axial ribs, forming flattened gemmules at points of intersection, body-whorl with 3 additional strong spirals, lower two of which

are not reached by ribs; suture channelled; aperture oval, angled above, produced below into short oblique canal which does not appear to have been notched at base; outer lip thin, inner lip with callus; columella slightly excavated.

Holotype in collection of the New Zealand Geological Survey.

Height, 9 mm.; diameter, 4·5 mm.

Locality.—1063, shell-bed, Okawa Creek, Ngaruroro River.

Remarks.—Easily distinguished from *A. huttoni* (Cossmann) by its having only 3 spirals on the spire-whorls and 6 on the body.

Ataxocerithium suteri n. sp. (Plate 17, fig. 2.)

Shell of moderate size, heavy, subulate; spire over 3 times height of aperture, whorls flat, 9 remaining in holotype, apex broken in all cases, body-whorl rounded, not keeled, contracted quickly to short, straight neck; sculpture of 3 strong spirals, intersected by 15–17 somewhat broader ribs which form prominent oval flat gemmules at points of intersection, on body is a narrow spiral coming in between the two anterior ones, below line of suture are 3 other moniliform spirals, anterior one weak, below these are fine weak spiral threads on neck of canal; suture canaliculated by spirals, sometimes with edge of fourth one showing; aperture broken in all cases, but apparently ovate, slightly channelled above, produced below into very short twisted oblique canal which runs along truncation of columella; columella straight, obliquely truncated below with well-developed median plait and obsolete anterior one bounding truncation; inner lip with thick callus, which, however, does not always hide the strong basal spirals, giving the appearance of a fold or folds on parietal wall.

Holotype in collection of the New Zealand Geological Survey.

Height, 19 mm.; diameter, 6 mm.

Locality.—1063, shell-bed, Okawa Creek, Ngaruroro River.

Remarks.—Suter had marked similar specimens from locality 691, Petane, as *Newtoniella* n. sp., but the plait on the columella in addition to the obsolete fold along the truncation seems to separate it from that genus, which according to Iredale (1915, p. 455) should be called *Cerithiella.*

Eulima christyi n. sp. (Plate 17, figs. 5, 11.)

Shell relatively large, imperforate, subulate, smooth and glossy, axis slightly curved above; spire high, conic; protoconch small, depressed, bulbous, of 2 smooth volutions; whorls 11 besides protoconch, with flattened sides, slightly swollen above suture, body-whorl large, subangled on joining base which is rapidly contracted and slightly convex; sculpture of sigmoid growth-lines, and obsolete varices of former apertures; aperture ovate, entire; outer lip thin, sinuous; inner lip with callus, definitely limited on base.

Holotype in collection of the New Zealand Geological Survey.

Height, 18 mm.; diameter, 5·5 mm.

Locality.—1089, blue clays, Okauawa Creek, Ngaruroro River.

Remarks.—Resembles *E. vegrandis*, but is much larger and comparatively a great deal broader.

Named in honour of Mr. C. Tait, of Maraekakaho, whose interest in the work and knowledge of the district were invaluable to the collectors.

Verconella dubia n. sp. (Plate 17, fig. 18.)

Shell of moderate size, very strong; spire less than aperture and canal; whorls 6 besides protoconch, subconvex, flattened below suture, body-whorl contracted quickly at base, with long neck twisted to left and backwards; protoconch of 2 smooth volutions, in shape of a flattened dome; sculpture of 10 strong but short axial ribs with equal interstices, extending from suture to suture on early shell, but later becoming shorter and not extending over base of body-whorl, spiral sculpture of 7 strong threads with weaker one filling each interstice, body-whorl with over 20 strong threads, also weaker ones between each pair; suture slightly undulating; aperture oval, lightly channelled above, produced below into long narrow canal very slightly sinused at end; outer lip lightly sinuous, antecurrent to suture, with sharp edge, but thickened and strongly toothed within; columella fairly long, somewhat concave above, twisted below at junction with neck; inner lip calloused, with strong denticle on parietal wall near suture, several weak ones scattered along its length and 2 or 3 stronger ones grouped together below.

Holotype in collection of the New Zealand Geological Survey.

Height, 30 mm.; diameter, 15·5 mm.

Locality.—1093, blue clays, Kikowhero Creek, Ngaruroro River.

Remarks. The inner lip is the same as that of *Evarne striata* (Hutton), but the outer lip is thick and strongly dentate. Apart from the denticles round the aperture the shell resembles a *Verconella*, but a complete survey of the generic affinities would involve so many already-described species that it hardly comes within the scope of this paper. The ornamentation resembles that of *V. thomsoni*, but that species has a straighter canal.

Verconella thomsoni n. sp. (Plate 17, fig. 19.)

Shell of moderate size, heavy; spire less than aperture and canal; whorls 6 besides protoconch, convex, somewhat flattened below suture, body-whorl large, contracted fairly regularly to long neck which is very slightly twisted: protoconch a small flattened dome of 2 smooth whorls; sculpture of 11 strong axial ribs per whorl with equal interstices, reaching from suture to suture, but much stronger in middle, vanishing on base, spiral ornamentation of about 7 strong threads with weaker one in each of interstices, body-whorl with about 22 strong spirals, generally with weak one (sometimes 2 or 3) in interstices, the last 10 spirals on neck are weak and rendered somewhat scaly by growth-lines; suture undulating; aperture oval, channelled above, produced below into long narrow but slightly twisted canal, very shallowly sinused at end; outer lip sinuous, antecurrent to suture, with sharp edge, but much thickened and dentate within, most of denticles extending back within shell as lirae; columella slightly concave, angled at junction with canal; inner lip calloused, produced well along canal to sharp point and limited externally by definite margin, there is strong posterior parietal denticle, and 7 weaker ones below, bottom 4 grouped near base of columella.

Holotype in collection of the New Zealand Geological Survey.

Height, 31 mm.; diameter, 16 mm.

Locality.—1092, blue clays above Te Aute limestone, Maharakeke Road, one mile south of Pukeora Sanatorium, Waipukurau.

Remarks.—This species resembles *V. dubia* n. sp., but has a straighter canal and a shorter, broader spire. The generic position under *Verconella* is only provisional. Named in honour of Dr. J. A. Thomson, who collected at this locality.

Aethocola taitae n. sp. (Plate 17, fig. 16.)

Shell of moderate size, fusiform; spire gradate conic, equal to aperture and canal; whorls 7 strongly angled, body-whorl with subangled keel, then contracted quickly to neck which is twisted and has a well-marked fasciole; protoconch conoidal of about 4 smooth volutions; sculpture of neanic shell with about 6 smooth ribs with equal interstices before spiral ornamentation begins, 4 spirals then appear in interstices, after a little they surmount the ribs but are never as strong as them; first 2 conch-volutions convex, but from then onwards the shell is strongly shouldered with about 12 strong ribs with wider interstices; ribs are raised into sharp tubercles on shoulder-angle, but obsolete above that and die away on base of body-whorl, angulation takes place on second anterior spiral, so early whorls have 2 threads on shoulder, a stronger one on angle, and another strong one midway to suture below, there are finer secondaries in the broad interspaces, on later whorls secondaries increase in number and some become as strong as primaries, base of body-whorl has 8 strong well-spaced cords with many secondaries, finer spirals are reticulated by equally fine growth-lines; suture undulating; aperture oblique, angled above, produced below into fairly long wide open canal twisted backwards and deeply notched at base; outer lip thin and sharp, lirate within, antecurrent to suture; columella smooth, slightly arcuate; inner lip thin, not extending over base.

Holotype in collection of the New Zealand Geological Survey.

Height, 34 mm.; diameter, 18·5 mm.

Locality.—Blue clays below limestone, Kikowhero Creek, Ngaruroro River.

Remarks.—This shell was placed by Suter under *Siphonalia nodosa* (Martyn), and it is certainly closely related; probably it can be regarded as an ancestor. It differs from *nodosa* in having fewer and stronger ribs and tubercles, stronger spirals, and a flatter shoulder. Generic rank is here given to *Aethocola*, which Iredale (1915) set up as a subgenus of *Verconella*. The anterior canal is deeply notched at the base, so the genus belongs to the Buccinidae, while *Verconella*, which is not notched, belongs to the Chrysodomidae. Named in honour of Mrs. G. Tait, of Maraekakaho.

Cominella hamiltoni (Hutton). (Plate 17, fig. 4.)

1885. *Clathurella hamiltoni* Hutton, *Trans. N.Z. Inst.*, vol. 17, p. 316, pl. 18, fig. 7.

1893. *Clathurella hamiltoni* Hutton, *Macleay Mem. Vol.*, p. 52, pl. 7, fig. 35.

1915. *Cominella huttoni* Kobelt: Suter, *N.Z. Geol. Surv. Pal. Bull. No. 3*, p. 25 (not of Kobelt).

Shell small, broadly fusiform; spire slightly higher than aperture with canal; whorls 6, with high narrow shoulder, level with suture, body-whorl comparatively large, contracting fairly rapidly to short neck which is marked by a prominent fasciole; protoconch a flat dome of 2 smooth whorls (= tectiform, or "*en goute de suif*," Cossmann, 1895, p. 12); sculpture—first conch-whorl with strong ribs curving forward on lower part of whorl, after first volution about 6 spiral threads appear, these surmount ribs and increase in number until there are about 12 on penultimate whorl with equal interstices, body-whorl with 20 of which anterior 8 are stronger than others, ribs number about 12 on spire-whorls and 15 on body, are very strong and, passing over narrow shoulder, reach suture above, but become weaker on base and then die out; suture undulating; aperture oval, channelled

above, and with short wide anterior canal bent to left and deeply notched; outer lip sharp, slightly sinuous, smooth within; columella slightly arcuate; inner lip calloused, produced along edge of canal and ending in sharp point.

Holotype in collection of the Canterbury Museum.

Height, 16 mm.; diameter, 9 mm.

Locality.- Clays below limestone, Petane.

Remarks.—This *Cominella* is a very common one in the Petane clays of the Hawke's Bay District. By Suter it was identified as the Recent *C. quoyana* (A. Ad.) (= *huttoni* Kobelt), but it is easily distinguished by the strong narrow ribs persisting to the suture above, and the strong spiral threads with interstices of equal width.

Trophon murdochi n. sp. (Plate 17, figs. 12, 13.)

Shell small, fusiform; with turreted spire equal in height to aperture and canal; whorls 4 besides protoconch, early ones with flat shoulder, later ones convex but still flattened below suture, body-whorl about three-quarters total height, contracted gradually on base to form fairly long stout neck with slight twist to left and backwards and with moderate fasciole at base; protoconch proboscidiform, of 2 smooth whorls, the first small and well tilted, the second increasing to a comparatively large size and coiled in axis of shell; sculpture—first conch-volution of much greater diameter than protoconch, so there is quickly developed a wide flat shoulder, which later becomes more sloping and relatively narrower, spiral sculpture of 3 strong cords with wider interstices, the lowest appears first on the conch-whorl, soon afterwards the middle one and then the top one at angle of shoulder, a fourth spiral appears in suture near aperture, while there is a weak one on shoulder of last two whorls, body with 8 strong spirals besides weak one on shoulder, whole surface covered with close fine sharp varices, stronger in interstices; suture well impressed; aperture oval, subangled above, produced below into fairly long twisted canal well notched at base; outer lip thin, slightly sinuous, as far as can be seen, smooth within; columella straight, smooth; inner lip smooth, ending a short way along canal.

Holotype in collection of the New Zealand Geological Survey.

Height, 13 mm.; diameter, 7 mm.

Locality.—1099, clays below limestone, road-cutting, Maraekakaho.

This species is easily distinguished from the other New Zealand examples of the subgenus by its fusiform shape and the number of spirals on the body-whorl.

Xymene drewi (Hutton). (Plate 17, fig. 8.)

1883. *Cominella drewi* Hutton, *Trans. N.Z. Inst.*, vol. 15, p. 410.
1893. *Pisania drewi* Hutton, *Macleay Mem. Vol.*, p. 42, pl. 6, fig. 13.
1915. *Euthria drewi* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull. No. 3*, p. 23.

The type material consists of two specimens, the larger of which was selected by Suter as lectotype and wrongly called "holotype" by him. Hutton's measurements agree with neither, but he appears to have given the dimensions of the largest specimen he knew of in many cases, irrespective of his type material. The two specimens do not agree even generically: the larger one has a parietal tooth and two small ones at the base of the columella, being closely related to "*Tritonidea*" *compacta* Suter; the smaller one is what has generally been considered as *Euthria drewi*, and is the specimen figured in the *Macleay Memorial Volume.* It has therefore a

better claim to be considered the type of *E. drewi* than has the shell chosen by Suter. Further, in the original description Hutton says there are about 22 spirals on the body-whorl; Suter's lectotype has 12, while the smaller specimen figured below has 18.

Height, 13 mm.; diameter, 7 mm.

Generically this shell cannot be separated from *Xymene plebeius* (Hutton), from which it differs in the non-carination of the whorls.

Xymene oliveri n. sp. (Plate 17, figs. 7, 10.)

1886. *Trophon crispus* Gould: Hutton, *Trans. N.Z. Inst.*, vol. 18, p. 347 (not of Gould).

1893. *Trophon crispus* Gould: Hutton, *Macleay Mem. Vol.*, p. 40, pl. 6, fig. 8 (not of Gould).

Shell small, fusiform, imperforate; spire acute, equal to aperture and canal; whorls 6, convex, body-whorl with a high blunt shoulder, base contracted fairly quickly to short slightly curved neck; protoconch broken in all specimens seen; sculpture on early whorls two strong spirals with weaker one above, later another cord appears just above suture, body-whorl with 11 cords, with slightly wider flat interstices, each whorl has about 15 axial ribs of a variciform nature as they are traversed longitudinally by sharp growth-lamellae which appear also in interstices, in addition a fairly prominent varix is sometimes present on body-whorl, marking a former aperture; suture well impressed; aperture oval, produced below into short oblique recurved canal very slightly notched at end; outer lip constricted suddenly to canal, varixed on outside with a sharp edge bevelled within and crenulate or denticulate; columella slightly arched, meeting canal in prominent angle; inner lip smooth, calloused, extending half-way along canal.

Holotype in Canterbury Museum.

Height, 9 mm.; diameter, 5 mm.

Locality.—Petane.

Remarks.—Hutton's classification of this shell under Gould's species, which belongs to Tierra del Fuego, was quite tentative. On both occasions quoted above he says that the New Zealand shell "may be distinct." Evidently he was judging from figures. It is most unlikely that the shells should be specifically the same, considering their distribution. An examination of Gould's description (1852) shows important differences, among which are "length nearly an inch . . . 8 or 9 prominent subangular varices." The New Zealand shell is less than half this length, and has about 15 variciform axials; it should therefore be regarded as a distinct species. Cossmann (1903, p. 54, footnote) changed *Trophon crispus* (Gould) to *Trophon gouldi*, giving as his reason, "Cette denomination fait double emploi avec celle d'un *Murex* bien antérieur, dans l'Eocene du Bassin de Paris; l'espèce néozélandaise doit donc recevoir un autre nom." Now, the shell in question was described originally (Gould, *Proc. Boston Soc. Nat. Hist.*, 3, p. 141, 1849) as *Fusus crispus*, so there is no justification for changing the specific name, as the Parisian shell is still retained under *Murex*. *T. gouldi* cannot, however, be applied to the New Zealand shell; it was definitely proposed as a substitute for *T. crispus*, and must be associated with that South American species.

Anachis speighti n. sp. (Plate 17, fig. 1.)

Shell small, fusiform; spire straight, slightly higher than aperture; whorls 5 besides protoconch, with flat or slightly convex outlines, body-whorl more than half height of shell, with rounded base constricted to short

neck, which is bent slightly to left and backwards; protoconch elevated naticoid, of 2 smooth glassy whorls definitely marked by their texture from the neanic shell; suture impressed, bordered below; sculpture of about 20 strong axial ribs with narrower interstices extending from suture to suture but dying out on base, there are spiral grooves with wider interspaces which appear only in interstices of axials, 5 on penultimate and 4 on spire-whorls, on base the spiral interspaces are raised into rounded cords about 8 in number, spiral groove first below suture is generally stronger than the others, giving suture a bordered appearance; aperture rhomboidal, angled above, produced below into short wide canal, lightly notched at end; outer lip straight, sharp, thickened within with a few obsolete teeth; columella short and straight, with low oblique fold at junction with canal; inner lip smooth, with thin layer of callus ending in acute angle half-way down canal.

Holotype in the Canterbury Museum.

Height, 10·5 mm; diameter, 4·5 mm.

Locality.—Petane, clays below limestone.

Remarks.—This shell is not uncommon in the Petane clays, but was not separated by Hutton from *A. pisaniopsis*; the holotype was, indeed, among his syntypes of that species. *A. speighti* is easily separated from *A. pisaniopsis* and *A. cancellaria* by its stouter form, flat whorls, bordered suture, stronger axials especially on the body, and spiral grooves appearing only in the rib-interstices on the spire-whorls. Figures of the holotypes of *A. pisaniopsis* and *A. cancellaria* are given for comparison. (See Plate 17, figs. 3 and 20.)

Alcithoe lutea n. sp. (Plate 17, fig. 17.)

Shell large, ovato-fusiform; spire conic, two-thirds height of aperture; whorls 6, subangled about middle on spire, body-whorl with strong tuberculate keel, contracting very slowly to well-marked basal fasciole; protoconch bulbous, of about 2½ smooth volutions; sculpture—the early whorls have about 14 obsolete ribs slightly stronger at shoulder-angle, on penultimate and body-whorls these form strong rounded tubercles, about 7 on latter, there is no spiral sculpture; aperture high triangular, channelled above, broadly and deeply notched below; outer lip thickened, reflexed, ascending penultimate whorl, smooth within; columella inclined, with four strong oblique folds and sometimes a fifth weak posterior one; inner lip callused, widely spread over base and canal.

Holotype in collection of the New Zealand Geological Survey.

Height, 92 mm.; diameter, 38 mm.

Locality. Blue sandy clays, Okauawa Creek Ngaruroro River.

Remarks. This species is closely related to and is probably the direct ancestor of *Alcithoe arabica*, from which it is readily distinguished by its relatively much higher spire (two-thirds instead of one-half aperture), which gives the shell a different shape. There are also fewer and stronger tubercles on *A. lutea*, and the columella has generally 4, rarely 5, folds. *A. arabica* has generally 5, and often 6 or 7. *Alcithoe*, of which the genotype is *A. arabica*, was treated as a subgenus of *Fulgoraria* by Suter, following Cossmann; but since the protoconch of the former genus is not laterally coiled, as it is in the latter, *Alcithoe* should take generic rank, and replace *Fulgoraria* in New Zealand lists.

Ancilla (Baryspira) opima n. sp. (Plate 17, fig. 15.)

Shell small, strong, ovate; spire short and broad, with sharp apex; protoconch small, almost free from enamel; sculpture, spire, and upper

part of body-whorl covered with smooth, moderate callus, middle zone of body-whorl with growth-lines only, separated from basal limb by a comparatively narrow depression; aperture slightly oblique, oval, deeply notched below; outer lip convex, thickened above but thin below and with denticle opposite spiral depression; columella slightly concave, truncated below; inner lip calloused, with pad extending over parietal wall and nearly to protoconch.

Holotype in collection of the New Zealand Geological Survey.

Height, 16·5 mm.; diameter, 11 mm.

Locality.—1104, "Fossil Creek," west of Cottage Road, Maraekakaho.

Remarks.—This species was confused by Suter with *A. depressa* (Sowerby) because of its squatness, but it is comparatively much broader than that species.

Marginella (Glabrella) brevespira n. sp. (Plate 17, fig. 6.)

Shell relatively large, oval; spire inconspicuous; protoconch a large flattened dome; whorls 3 besides protoconch, with flat outlines on spire, but body-whorl plump and inflated; sculpture none, surface smooth and shining; aperture long, slightly wider below; outer lip thickened, varix ascending to top of penultimate whorl, inside obsoletely toothed; columella with 4 strong oblique folds, the lower two more oblique than the upper.

Holotype in collection of the New Zealand Geological Survey.

Height, 10 mm.; diameter, 5 mm.

Locality. Sandy beds in blue clays below limestone, three miles above mouth of Maraekakaho Creek.

Remarks. This shell is closely related to *M. kirki* Marwick, but may be distinguished by the plump convex outline of the body-whorl and the very short spire with flat sides.

Mangilia morgani n. sp. (Plate 17, fig. 14.)

Shell of moderate size, fusiform; spire slightly higher than aperture and canal; whorls 7, convex, protoconch broken off, later whorls with short sloping shoulder and blunt angle, base gradually contracted; sculpture of strong axial ribs and wide interstices passing from suture to suture, increasing from 8 to 12 on spire-whorls, becoming shorter and finally dying out on body, last seen on shoulder; spiral striae obsolete, sometimes more distinct on base; aperture ovate, produced below into short wide canal not notched anteriorly; outer lip expanded, with shallow sinus between shoulder-angle and suture; columella straight, with 2 insignificant folds; inner lip thin.

Holotype in collection of the New Zealand Geological Survey.

Height, 17 mm.; diameter, 8 mm. (a paratype is 19 mm. by 8 mm.).

Locality.—1063, shell-bed, Okawa Creek, Ngaruroro River.

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Notes and Descriptions of New Zealand Lepidoptera.

By E. Meyrick, B.A., F.R.S.

Communicated by G. V. Hudson, F.E.S., F.N.Z.Inst.

[*Read before the Wellington Philosophical Society, 30th September, 1921; received by Editor, 6th November, 1922; issued separately, 6th June, 1924.*]

Caradrinidae.

Melanchra distracta n. sp.

♀. 37 mm. Head and thorax mixed dark grey and white, with irregular oblique dark streaks. Palpi dark grey sprinkled white, terminal joint rather long. Abdomen pale fuscous. Forewings elongate-triangular, termen waved; grey suffusedly irrorated white, veins marked with interrupted blackish lines; first and second lines double, waved-dentate, blackish-grey, rather curved, second very strongly near costa; median shade rather curved, grey, on costa forming an oblique blackish streak, orbicular little marked, large, round, grey-whitish centred with grey suffusion, reniform trapezoidal, white, interior filled with whitish-grey, anterior edge subconvex, posterior concave; subterminal line indicated by an inwards-oblique streak of dark-fuscous suffusion from costa towards apex and a similar somewhat interrupted streak from termen beneath apex to dorsum before tornus, terminal area round these suffused whitish; black terminal interneural dots or marks: cilia grey slightly sprinkled white. Hindwings light fuscous, posterior half suffused rather dark grey; cilia fuscous, tips whitish-mixed.

Mount Ruapehu, 4,000 ft., in January (Hudson); one specimen. Perhaps nearest *cucullina.*

Hydriomenidae.

Venusia autocharis n. sp.

♂♀. 28 mm. Head orange-ferruginous, a white frontal bar. Palpi, thorax, and abdomen ochreous-orange. Antennae white, pectinations light grey Forewings somewhat elongate-triangular, termen bowed, oblique; ochreous-orange, towards costa tinged lilac, costal edge in ♂ anteriorly suffused dark grey and slightly speckled white; a slightly sinuate lilac-fuscous fascia from dorsum before middle to apex of wing; in ♂ a rather dark fuscous dot in middle of disc, and veins towards dorsum and termen somewhat tinged whitish and dotted with dark-fuscous suffusion: cilia orange, paler towards tips. Hindwings pale ochreous-yellowish, whitish-tinged in ♂, towards termen suffused light ochreous-orange; cilia as in forewings.

Mount Ruapehu, 4,000 ft., in January (Hudson); three specimens. Near *charidema*, but distinct.

Crambidae.

Diptychophora parorma n. sp.

♂. 13–14 mm. Head ochreous-whitish. Palpi ochreous-whitish mixed with grey. Thorax whitish mixed with dark grey. Forewings with termen more oblique than in *elaina;* whitish, slightly sprinkled grey; base spotted with blackish-grey, then some blackish-grey irroration tinged with whitish-ochreous, followed by first line, which is irregular, black, angulated outwards in disc and inwards towards termen; an obscure curved rather broad median shade of grey suffusion mixed with whitish-ochreous, above

its middle an irregular X-shaped black mark, lower angle resting on a roundish white spot; second line double, fine, grey, curved, waved, indented on fold; a terminal fascia of grey suffusion, including apical dot preceded by a white crescentic mark, and six black semicircular terminal dots more or less edged whitish anteriorly: cilia whitish, a dark-grey basal line and greyish subapical line. Hindwings light grey, a curved whitish line at ⅔, and a whitish terminal line, terminal edge grey; cilia whitish, a light-grey subbasal line.

Mount Ruapehu (2,800 ft.), Wainuiomata, in December and January (Hudson); two specimens. Very like *elaina*, but immediately distinguished by the black terminal dots, of which there is no trace in *elaina*.

Tortricidae.

Catamacta transfixa n. sp.

♂. 15 mm. Head and thorax dark purplish-fuscous mixed with dark red-brown. Palpi dark fuscous. Antennal ciliations 1. Forewings sub-oblong, costa anteriorly gently arched, with rather broad fold from base to beyond ⅓, termen sinuate, oblique; ferruginous-brown suffusedly reticulated with glistening greyish-violet; a narrow suffused ochreous-whitish median streak from base to termen, similar streaks on veins 6 and 7, on vein 3, and space between this and tornus suffusedly irrorated ochreous-whitish: cilia ferruginous-brown mixed whitish, tips whitish, at apex a violet-grey bar. Hindwings pale grey, very faintly mottled; cilia whitish.

Wellington, in December (Hudson); one specimen.

Tortrix zestodes n. sp.

♂. 14 mm. Head ferruginous. Palpi ferruginous-brown, tip mixed dark fuscous. Antennal ciliations 1½. Thorax ferruginous mixed dark fuscous Forewings elongate, slightly dilated, costa anteriorly gently arched, without fold, termen nearly straight, little oblique; ferruginous-ochreous; basal patch ferruginous, edge rather irregular, oblique; central fascia ferruginous-brown, rather broad, very oblique, confluent except towards costa with a broad ferruginous-brown terminal fascia: cilia ferruginous, with tips pale, towards tornus grey, on costa barred grey. Hindwings dark grey, on posterior half dotted pale grey; cilia light grey, with dark-grey subbasal line, tips on apex and upper part of termen whitish-ochreous.

Flora Camp, Mount Arthur, 2,500 ft., in January (Miss Stella Hudson); one specimen. Nearest *crypsidora*.

Gelechiadae.

Gelechia lapillosa n. sp.

♂. 15–16 mm. Head, palpi, and thorax slaty-grey, somewhat speckled whitish. Forewings rather narrow, apex pointed, termen very obliquely rounded; dark slaty-fuscous, irregularly sprinkled or mixed whitish-grey; markings cloudy, formed by absence of pale mixture, or in one specimen blackish; spots representing stigmata, plical rather obliquely before first discal, a thick oblique bar from costa terminating in these two, an additional spot midway between plical and base; an angulated grey-whitish transverse shade at ¾ more or less distinct: cilia light grey, basal half somewhat sprinkled dark fuscous. Hindwings and cilia light grey.

Mount Ruapehu, 4,000 ft., in January, "very common in river-bed" (Hudson); four specimens. Next *lithodes*.

Gelechia aerobatis n. sp.

♂. 15 mm. Head, palpi, and thorax light-greyish. Forewings rather narrow, pointed, termen very oblique; rather light-brownish, darker towards base; a rather broad whitish costal streak nearly from base to $\frac{4}{5}$, narrowed near base, posterior extremity suffused, a slender suffused dark-grey streak on costal edge from before middle of wing to $\frac{2}{3}$; discal stigmata rather elongate, dark fuscous, touching lower edge of whitish streak, plical slightly marked or obsolete, somewhat before first discal: some fuscous irroration running from second discal to beneath apex; costa posteriorly and termen interruptedly lined fuscous: cilia pale-greyish, round costa and apex suffused whitish. Hindwings light grey; cilia pale-greyish.

Mount Arthur, 4,000 ft., in January, one example taken by myself, also a second at 3,500 ft. by Mr Hudson. Between *pharetria* and *monophragma*.

Phthorimaea heterospora n. sp.

♂. 11 mm. Head whitish-grey-ochreous or grey-whitish. Palpi grey sprinkled whitish, terminal joint whitish anteriorly suffused dark fuscous except towards base. Thorax whitish with central whitish-ochreous stripe, patagia greyish-ochreous. Forewings rather narrow, apex pointed, termen straight, extremely oblique; light brownish-ochreous, on costal half suffusedly irrorated fuscous, between stigmata and on terminal area sprinkled whitish, dorsal area beneath fold suffused whitish; discal stigmata variably indicated by irregular dark-fuscous irroration, approximated, plical in one specimen well-marked, black, somewhat before first discal, sometimes a streak of dark-fuscous suffusion on fold towards base; costa posteriorly and termen sprinkled dark fuscous: cilia pale greyish-ochreous mixed whitish or wholly grey-whitish. Hindwings and cilia pale grey or grey-whitish.

Mount Ruapehu, 4,000 ft., in January (Hudson); two specimens.

GLYPHIPTERYGIDAE.

Glyphipteryx calliactis Meyr.

Mr. Hudson has sent me a bred female of this species; it differs remarkably from the male in having the slender greyish-ochreous streaks from dorsum at $\frac{1}{5}$ and beyond middle replaced by oblique slightly-curved wedge-shaped ochreous-white spots, the apical half of second violet-golden, the metallic portions of the costal and dorsal streaks thicker, violet-golden, the terminal markings consisting of a violet-golden subapical dot, a short longitudinal mark before this, and a rather thick streak along lower part of termen.

GRACILARIADAE.

Acrocercops zorionella Huds.

This distinct species, of which I have received an example through the kindness of Mr. Hudson, is referable to *Acrocercops* and not to *Parectopa*.

PLUTELLIDAE.

Thambotricha n. g.*

Head with appressed scales; ocelli posterior; tongue developed. Antennae $\frac{5}{6}$, in ♂ slender, joints elongate, with spreading whorls of

* *Entomologist*, vol. 55, Dec., 1922, p. 270.

extremely long fine ciliations, basal joint moderate, rather stout, with rather small pecten. Labial palpi long, recurved, second joint thickened with scales forming a very short apical tuft beneath, terminal joint somewhat shorter than second, rather thickened with scales, pointed. Maxillary palpi very short, drooping, filiform. Posterior tibiae with series of rough projecting bristly scales above. Forewings with 1*b* furcate, 2 from $\frac{3}{5}$, 7 to termen, 11 from middle. Hindwings $\frac{4}{5}$, elongate-trapezoidal, cilia $1\frac{1}{2}$; 2 remote, 3 and 4 approximated at base, 5 7 somewhat approximated towards base.

A remarkable form, perhaps nearest *Dolichernis*, but very distinct.

Thambotricha vates n. sp.

♂. 14 mm. Head pale ochreous, side tufts bronzy. Palpi bronzy-fuscous. Antennal ciliations 8. Thorax purple-bronzy-ochreous. Abdomen whitish-ochreous. Forewings elongate, narrowed towards base, costa sinuate, apex pointed, termen faintly sinuate, oblique; pale yellow overlaid with purple-bronzy-ochreous, costal edge pale yellow from $\frac{2}{5}$ to $\frac{4}{5}$; discal stigmata remote, rather dark fuscous, an additional dot beneath and rather before second, these two partially surrounded with pale-yellowish; a slender terminal streak of purple-fuscous suffusion: cilia whitish-yellowish, on costa suffused purple-ochreous, darkest above apex, on dorsum pale ochreous tinged purple, cilia extending to before middle of dorsum. Hindwings and cilia ochreous-whitish.

Wellington, in March, one specimen swept from forest growth by a young collector, Edward C. Clarke, aged fourteen, and kindly forwarded by Mr. Hudson. It is permissible to hope that the discoverer of this very interesting species may be thus early inaugurating a distinguished entomological career.

Protosynaema quaestuosa n. sp.

♂♀. 12 13 mm. Head and thorax dark indigo-fuscous. Palpi greyish, terminal joint suffused dark bluish-fuscous anteriorly. Antennae grey, basal $\frac{3}{5}$ moderately thickened with dark-grey scales. Forewings rather narrow, apex obtuse, termen nearly straight, rather oblique, outline of terminal cilia rounded; dark purplish-fuscous; in one specimen a rather thick light-brownish streak along anterior half of fold; markings iridescent violet-golden-metallic, more or less broadly edged with brown suffusion; a slender oblique streak from costa near base to fold; a hardly curved slender transverse median streak, sometimes interrupted; a dot in disc at $\frac{3}{4}$, nearly touched by an erect streak from tornus; a dot on costa near apex; a narrow streak along termen, at and near lower extremity preceded by two black dots: cilia bronzy-grey, tips paler and submetallic, at apex sometimes whitish. Hindwings rather dark grey; cilia grey.

Mount Aurum, bred from larvae on native grasses in January (Hudson); five specimens. Closely related to *steropucha*, but distinguished by the grey naked apical portion of antennae (in *steropucha* white) and rounded outline of terminal cilia of forewings (in *steropucha* always perceptibly sinuate). The scale-thickening of antennae is less strong and less extensive than in *steropucha*, but varies in that species, as also do the metallic markings of forewings.

Orthenches chartularia n. sp.

♂. 16 mm. Head and thorax whitish. Palpi dark grey, tips of second and terminal joints white. Forewings elongate, apex obtuse-pointed,

termen slightly rounded, rather strongly oblique; whitish, irregularly strewn with dark-fuscous strigulae partially mixed with grey suffusion; four small dark-fuscous spots on costa from before middle to ⅚, and four somewhat larger in a median longitudinal series from ⅙ to ⅚; four dark-fuscous dots on posterior half of dorsum: cilia whitish, a grey basal shade, at apex a grey bar. Hindwings grey-whitish; cilia whitish.

Mount Ruapehu, 4,000 ft., in January (Hudson); one specimen.

TINEIDAE.

Astrogenes chrysograpta Meyr.

♂ ♀. 12–14 mm. Three fine examples from Mount Ruapehu, 2,800 ft. (Hudson); these have the last three metallic dots of costa wholly absent or very slightly indicated, but after very careful examination I am satisfied that they are the same species. Mr. Hudson states, "Taken amongst *Cordyline*, very local."

Tinea cymodoce n. sp.

♂. 11 mm. Head fuscous, face with a few whitish hairs, orbits whitish. Palpi white, second joint sprinkled fuscous. Thorax rather dark fuscous, edges of patagia white. Forewings elongate, apex obtuse-pointed, termen very obliquely rounded; bronzy-fuscous; some whitish suffusion towards costa anteriorly, a very fine white longitudinal stria from base beneath this, on dorsal half from base to middle several very fine short whitish striae; a slender oblique white streak from costa at ⅓ not reaching half across wing, two approximated slightly sinuate from costa about middle reaching half across wing, two approximated shorter and little oblique at ⅔, two separate nearly direct beyond these, and two very short white triangular marks before apex; three somewhat oblique slender whitish streaks from dorsum at ⅓, middle, and ⅔, not reaching half across wing, some dark-fuscous suffusion between these; a short slightly oblique whitish streak from dorsum near tornus, one erect at tornus, and one in middle of termen, all these becoming suffused and silvery upwards, a dot of silvery suffusion in disc at ⅚; a small silvery-whitish mark beneath apex: cilia light bronzy-grey with slender white bars on markings, a black basal line. Hindwings dark purplish-grey; cilia grey, darker towards base.

Mount Arthur, 3,600 ft., in January (Hudson); Mr. Hudson has also an example from Mount Ruapehu. Near *astraea*.

Endophthora tylogramma n. sp.

♂. 7 mm. Head ochreous-whitish. Palpi dark fuscous. Thorax grey-whitish, patagia and a dorsal stripe suffusedly mixed blackish. Forewings elongate-lanceolate; purple suffused light grey, and irregularly mixed blackish; a narrow irregular white dorsal streak from near base, forming three irregular spots filled with light greyish-ochreous except on margins at ¼, middle, and ¾, dorsal area above these suffused blackish, beyond these a very fine white line along termen to apex: cilia light-greyish. Hindwings bronzy-purple-grey; cilia light grey.

Wellington, in March, "swept from forest growth" (Hudson); one specimen. I have not been able to determine the neuration accurately, but it agrees nearly with that of *Endophthora*, and some variation would be permissible; superficially the species is a very distinct one.

Notes and Descriptions of New Zealand Lepidoptera.

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NOCTUIDAE.

Ichneutica dives n. sp.

♂ ♀. 39–46 mm. Head and palpi ferruginous sprinkled with grey, apex of terminal joint of palpi grey-whitish. Antennae ochreous, in ♀ whitish, ferruginous beneath, pectinations in ♂ ½. Thorax ferruginous, thickly irrorated with grey, collar grey-whitish. Abdomen fuscous-grey. Legs ferruginous sprinkled with grey, all tarsi annulated with grey-whitish. Forewings moderate, costa almost straight, apex obtuse, termen rounded, oblique; *ferruginous, irrorated with white and grey;* an irregular white basal line, interruptedly margined with black anteriorly; first line irregular, bent inwardly beneath costa, broadly excurved at middle, white, posteriorly black-margined; claviform pale-centred, black-margined, touching first line; orbicular round, pale-centred, black-margined, half-way between first line and reniform; reniform pale-centred, black-margined laterally; a white dot on costa above reniform; second line irregularly dentate, excurved on upper ⅔, incurved beneath, white, black-margined anteriorly; subterminal line parallel with termen, obscure, grey-whitish; interruptedly margined with blackish anteriorly; terminal area paler: cilia ferruginous, obscurely barred with whitish. Hindwings fuscous-grey; a dark line round termen: cilia fuscous-grey with faint dark basal line, tips more or less whitish. Female in all respects much paler than male.

Distinguished from the other species of the genus by the ferruginous ground-colour.

Mount Arthur Tableland, at an elevation of 4,500 ft. Five males and two females taken at "sugar" in December and January. Holotype (♂), allotype (♀), and paratypes in coll. Cawthron Institute.

Persectania similis n. sp.

♂ ♀. 38–40 mm Head and palpi reddish-brown sprinkled with white. Antennae reddish-brown, basally white, in male with short cilia. Thorax with slight blunt anterior crest, greyish-white; a white frontal bar, margined beneath with blackish-brown and above with reddish-brown; patagia margined with reddish-brown. Abdomen in ♂ brown, in ♀ grey. Legs reddish-brown, tarsi mixed with white. Forewings *narrow,* costa almost straight, *apex blunt-pointed,* termen rounded, oblique; *bright reddish-brown irrorated with whitish;* basal area above middle for about ¼ in ♂ clearer white, in ♀ less marked and extending farther along costa; a fine blackish median streak from base to ½, margined beneath with dark reddish-brown; a broad streak along dorsum suffused with whitish; first line strongly dentate, white, posteriorly brown-margined, hardly traceable on upper half; an indistinct blackish line in disc above middle; second line hardly distinguishable, blackish-margined, strongly dentate, apex of teeth marked by black dots; subterminal very strongly and irregularly dentate, dentations filled with whitish, anteriorly interruptedly blackish-margined; stigmata almost obsolete, in female orbicular and reniform

represented by obscure pinkish blotches: cilia reddish-brown, tips more or less whitish. Hindwings dark fuscous, in male reddish-tinged: cilia in ♂ grey, in ♀ basal half white, with interrupted dark basal line. Undersides fuscous-grey, pink-tinged, in ♀ paler.

In general appearance very like *P. ewingii* (Westw.) but narrower-winged and without the peculiar reniform of that species.

Gouland Downs. One of each sex taken in February. Holotype (♂) and allotype (♀) in coll. Cawthron Institute.

PYRAUSTIDAE.

Scoparia pura n. sp.

♂♀. 21-22 mm. Head grey mixed with fuscous. Maxillary palpi grey, labial fuscous. Antennae fuscous, in ♂ shortly ciliated. Thorax dark greyish-fuscous. Abdomen grey, anal tuft ochreous. Legs grey, anterior tarsi infuscated. Forewings moderately dilated, costa arched at base, thence straight, apex rounded, termen straight, oblique; grey, strongly suffused with white on basal area and beneath costa to second line; an interrupted blackish line at base; *first line indicated by thick brownish-black posterior margining, outwardly oblique on upper half, inwardly angled at middle;* orbicular dot-like, detached, black; reniform X-shaped, black; second line irregular, indented beneath costa, incurved on lower ⅔ and dentate above dorsum, white, strongly black-margined anteriorly; a marginal series of black dots, preceded by an obscure white shade: cilia fuscous-grey with a darker basal line. Hindwings greyish-fuscous, darker apically: cilia as in forewings. Female paler in all respects.

Near *S. nomeutis* Meyr., but structurally distinct in the much shorter antennal ciliations; the angled first line is also a good distinguishing character.

Common on the tableland of Mount Arthur at 4,000 ft. to 5,000 ft. in January. Holotype (♂), allotype (♀), and a series of paratypes in coll. Cawthron Institute.

Scoparia falsa n. sp.

♂♀. 21-24 mm. Head grey. Palpi brown, mixed with white on upper surface and white basally beneath. Antennae brown, very shortly ciliated in both sexes. Thorax grey mixed with blackish. Abdomen ochreous-grey. Legs whitish-ochreous, anterior tibiae and tarsi infuscated and annulated with ochreous. Forewings moderate, costa slightly arched, apex obtuse, termen faintly sinuate, oblique; pale brown, densely irrorated with white and with scattered blackish-brown scales; an indistinct short blackish-brown line from middle of base; first line obscure, evenly curved, white, margined on costa with brown; *a thick brownish-black discal streak from first line to reniform, margined beneath with brown;* claviform irregular, blackish, touching discal streak; reniform thick X-shaped, brownish-black, connecting with basal streak; second line obscure, white, anteriorly margined by a series of blackish dots, moderately indented beneath costa; veins interruptedly marked with blackish: cilia pale brownish mixed with white. Hindwings ochreous-grey, in ♀ fuscous tinged: cilia grey-whitish.

Belongs to *rotuella* group, but is not closely allied to any species.

A male and two females taken at Gouland Downs in February, and a male bred from moss taken from the Dun Mountains at about 2,000 ft.; the latter specimen emerged on 15th December. Holotype (♂), allotype (♀), and one paratype in coll. Cawthron Institute.

Scoparia gracilis n. sp.

♂ ♀. 16–19 mm. Head fuscous mixed with white. Palpi fuscous, white beneath basally and partially white above. Antennae fuscous, ciliations in ♂ ½. Thorax blackish-fuscous with a white anterior median spot and margins of patagia whitish. Abdomen dark greyish-fuscous. Legs greyish-fuscous, tarsi annulated with whitish. Forewings narrow, costa almost straight, apex rounded, termen slightly rounded, oblique; *pale-brownish, irrorated with black and white;* lines white; a very irregular white-margined black band at base; *first line curved, a little oblique with a slight indentation at middle,* posteriorly broadly margined on upper half with black; claviform rather large, detached, black; an outwardly-oblique broad white fascia from costa at middle, not reaching half across wing; reniform obscurely 8-shaped, lower half white, black above; second line broadly indented beneath costa, weakly curved to just above dorsum; subterminal broad, suffused, interrupted at middle; a thin terminal line: cilia greyish-fuscous with darker basal line. Hindwings greyish-fuscous: cilia as in forewings.

Near *S. critica* Meyr., but the form of the lines is different and there are no yellow markings.

Mount Arthur Tableland, 4,000 ft. to 5,000 ft. Fairly common in December, and one specimen taken in the middle of January. Holotype (♂), allotype (♀), and a series of male paratypes in coll. Cawthron Institute.

PTEROPHORIDAE.

Platyptilia ferruginea Philp., *Trans. N.Z. Inst.*, vol. 54, p. 150.

Since describing the above species from the unique ♀ taken at the Mount Arthur Tableland the male has been added to the collection of the Cawthron Institute, a single specimen of that sex having been secured by Dr. Tillyard at Gouland Downs early in February. It agrees exactly in colour and markings with the holotype, but is smaller, having a wing-expanse of only 18 mm., as against 21 mm. in the female.

TORTRICIDAE. (See also p. 212.)

Cnephasia latomana (Meyr.), *Trans. N.Z. Inst.*, vol. 17, p. 145.

I found this species fairly common on the Mount Arthur Tableland in December, at elevations from 4,000 ft. to 4,500 ft. The type specimen was a female, and, though Mr. G. V. Hudson took both sexes on Gordon's Pyramid in 1889, the male, as far as I am aware, has not been described. In appearance the sexes differ considerably, and it may be useful to briefly indicate the differences. While the ground-colour of the female is almost pure-white, that of the male is densely irrorated with fuscous and ferruginous. The area is also much reduced, so that the space is often almost wholly taken up by the markings. In the female the markings are ochreous-tinged, but in the male they are bright ferruginous. The hindwings of the male are dark fuscous, in strong contrast to the whitish ones of the female. The general effect is to produce a whitish female and a reddish male.

Tortrix argentosa n. sp.

♂ ♀. 16–17 mm. Head, palpi, and thorax greyish-white. Antennae grey, ciliations in ♂ ⅔. Abdomen ochreous-grey-whitish, anal tuft ochreous-white. Legs ochreous-white, anterior pair and spurs infuscated. Forewings

elongate, costa strongly arched, apex pointed, termen rounded, very oblique; *silvery white;* extreme edge of costa, from base to a varying point, blackish; a black dot in disc at ⅔, frequently absent: cilia greyish-white. Hindwings and cilia pale greyish-white.

Near *T. indigestana* Meyr., but whiter and without any reddish suffusion in disc.

Dun Mountain, at 3,000 ft. Eight males and one female taken flying in the evening among low shrubs and herbage. Holotype (♂), allotype (♀), and a series of ♂ paratypes in coll. Cawthron Institute.

OECOPHORIDAE.

Borkhausenia pallidula n. sp.

♂. 13–14 mm. Head pale whitish-ochreous. Palpi whitish-ochreous, outwardly infuscated. Antennae whitish-ochreous, annulated with fuscous, ciliation in ♂ 1. Thorax white mixed with pale fuscous. Abdomen ochreous-whitish, basal segments white, anal tuft brighter ochreous. Legs whitish-ochreous, more or less infuscated. Forewings rather elongated, costa evenly arched, apex blunt-pointed, termen rounded, very oblique; *white, irrorated with pale fuscous; many blackish-fuscous scales, tending to form an irregular spot in disc at ⅔ and a series of terminal dots:* cilia grey-whitish, fuscous-tinged apically, with a fuscous basal line. Hindwings grey-whitish, fuscous-tinged apically: cilia grey-whitish with an indistinct dark basal line.

An obscure but quite distinct form.

Gouland Downs, in February. A series of eight males beaten from undergrowth. Holotype (♂) and a series of paratypes in coll. Cawthron Institute.

GLYPHIPTERYGIDAE. (See also p. 213.)

Glyphipteryx octonaria n. sp.

♂. 11–13 mm. Head and thorax bronzy-fuscous. Palpi fuscous-black with five white bands. Antennae fuscous, clothed with grey pubescence. Abdomen fuscous. Legs greyish-fuscous, tarsi annulated with whitish. Forewings broad, posteriorly dilated, costa evenly arched, apex rounded, termen sinuate-indented, oblique; golden bronze, more fuscous at base and on area before tornus; eight violet-white metallic costal strigae, all more or less dark-margined; first, second, and third before middle, outwardly oblique, not reaching centre of wing; fourth beyond middle, oblique below costa, thence excurved to tornus, pink on lower ⅔; remaining strigae more distinctly whitish on costa and pink on lower portions; fifth outwardly oblique, joining sixth, which is transverse, and extending half across wing; seventh and eighth inwardly oblique, short; a violet-pink metallic patch on termen beneath costa and a larger one above tornus: cilia whitish, round apex bronzy-black but white opposite costal strigae. Hindwings dark fuscous, bronzy on apical half: cilia dark fuscous.

Near *G. codonias* Meyr., but a smaller species with differently arranged strigae.

Gouland Downs. Three males found on low forest herbage early in February. Holotype (♂) and two paratypes in coll. Cawthron Institute.

PLUTELLIDAE.

Orthenches similis n. sp.

♂ ♀. 14–16 mm. Head white, tinged with fuscous. Palpi fuscous, second joint with apical ring white, terminal joint mixed with white. Antennae alternately ringed with blackish-fuscous, and white interrrupted with fuscous scales. Thorax greyish-fuscous with purplish-violet sheen. Abdomen greyish-fuscous, anal tuft paler. Legs white, anterior pair infuscated and all tarsi annulated with fuscous. Forewings elongate, costa evenly arched, apex rounded, termen rounded, oblique; white, thickly irrorated with brown; markings dark brown; outer margin of basal patch very strongly oblique; an outwardly-oblique thick fascia from before middle reaching half across wing, enclosing a white spot in apical portion; tornal and terminal area dark brown, interrupted by upright white fascia from tornus which unites with white apical area of costa; two or three brown spots on costa above white tornal fascia; sometimes a series of white terminal dots: cilia greyish-fuscous with dark basal line, on costa mixed with white and sometimes with subapical and tornal white spots. Hindwings greyish-fuscous, darker apically: cilia greyish-fuscous with a dark basal line.

Very similar in appearance to *O. semifasciata* Philp., but the light and dark areas in that species are more pronounced, the ground-colour being less irrorated with brown.

Common at Nelson from November to January in *Nothofagus* forest to 2,000 ft. Generally beaten from a species of *Gaultheria*. Holotype (♂), allotype (♀), and a long series of paratypes in coll. Cawthron Institute.

NYMPHALIDAE.

Danaida chrysippus petilia Stoll., *Suppl. Cramer's Papillons Exotiques*, 132, pl. 28, f. 3.

An example of this butterfly was captured in January at Nelson by Mr. W. Wastney. Mr. G. V. Hudson (*Trans. N.Z. Inst.*, vol. 40, p. 104, 1908) published the first record of the species for New Zealand, a specimen having been brought to Mr. E. C. Sherlock, who states that he saw another at the same locality, a few miles from the Thames. Mr. Hudson gives a description and a figure. The Nelson specimen, which Mr. Wastney has kindly presented to the Cawthron Institute, is evidently the Australian subspecies *petilia*, and from Mr. Hudson's figure it would appear that the Thames specimen also belongs to that form. Both specimens are females.

PLUSIADAE.

Sericea spectans Guen., *Noct.*, vol. 3, p. 172.

A specimen of this common Australian species was captured by Mr. W. Wastney at Nelson in February, evidently a chance arrival from the Commonwealth. A short description is appended.

Expanse of wing, 88 mm. Head, thorax, and abdomen dark chocolate-brown. Forewings dark chocolate-brown, slightly ochreous-tinged on basal area and with violet metallic sheen in disc and towards dorsum; three or four irregular dark-brown fasciae near base; a double dark-brown fascia before middle; a broad dark-brown fascia beyond middle, broadly excurved on upper half to encircle a large black-ringed eye-spot; subterminal and terminal waved dark-brown lines. Hindwings dark chocolate-brown with a median pale-margined fascia and a tornal blackish blotch containing two bluish-white spots.

Somewhat similar in appearance to *Dasypodia selenophora* Gn., but easily distinguished, apart from the generic characters, by the violet sheen, the difference in the transverse fasciae, and the absence of the terminal series of white dots.

CRAMBIDAE.

Crambus abditus n. sp.

♂. 27 mm. Head ochreous-white. Labial palpi 4, ochreous-white. Maxilliary palpi white. Antennae ochreous-white. Thorax brassy-yellow. Abdomen and legs whitish-ochreous. Forewings moderate, costa evenly arched, *apex acute*, termen almost straight, very oblique; brassy-yellow; *costa margined throughout with white;* a straight well-defined white median longitudinal stripe, margined with fuscous above except near base, and more narrowly beneath on basal half; some obscure white terminal streaks above median streak: cilia white. Hindwings white, faintly tinged with ochreous: cilia white.

In the acute apex of the forewings this species recalls the much larger *C. angustipennis* Zell., but the markings are altogether different.

Bred by Mr. C. Lindsay from a larva found at Otarama, Canterbury, in October. Holotype (♂) in coll. Canterbury Museum.

TORTRICIDAE.

Tortrix scruposa n. sp.

♂. 17 mm. Head greyish-white. Palpi grey, terminal segment short and bluntly pointed. Antennae grey, ciliation 1. Thorax grey, patagia brown. Abdomen (missing). Legs grey, anterior pair infuscated. Forewings strongly arched at base, thence straight to apex, apex rounded, termen rounded, oblique; *white: markings bronzy-brown;* basal patch indicated by an irregular fascia, projecting at middle; *two curved fasciae beyond this, second broken up into spots:* median fascia directed towards tornus, evenly dilated from costa, interrupted at $\frac{2}{3}$; *four or five interrupted irregular fasciae between median fascia and apex:* cilia greyish-white, darker round apex. Hindwings fuscous grey: cilia grey with a darker basal line.

Not readily comparable with any other *Tortrix*.

Mount Ruapehu, in January. One male taken by Mr. C. C. Fenwick, who retains the type.

Tortrix subdola n. sp.

♂. 15–16 mm. Head greyish-white, face darker. Papli greyish-white, darker apically, second segment thickened with scales, apex truncate, terminal segment very short, hardly projecting. Antennae annulated alternately with fuscous and whitish, ciliations in ♂ $\frac{3}{4}$. Thorax fuscous-grey. Abdomen whitish-grey, anal tuft ochreous-white. Legs whitish-grey, anterior pair strongly infuscated. Forewings, costa strongly arched, apex pointed, termen rounded, very oblique; *silvery-white tinged with grey;* extreme edge of costa, for short distance basally, fuscous; median costal area more clearly white; *a speckling, consisting of groups of one to four black scales, throughout; a prominent black discal dot;* cilia whitish-grey with darker basal line. Hindwings and cilia greyish-white.

Very similar in appearance to *T. argentosa* Philp., but the black speckling is absent in that species. From *T. indigestana* Meyr. the structure of the palpi is a good distinguishing character.

Taken by Messrs. C. C. Fenwick and Morris N. Watt at Ruapehu in December and January. Five males were forwarded for examination. Holotype (♂) and paratypes in coll. C. C. Fenwick.

ELACHISTIDAE.

Elachista watti n. sp.

♂. 7-8½ mm. Head white, slightly mixed with pale fuscous. Palpi white. Antennae fuscous-grey. Thorax white mixed with fuscous. Abdomen greyish-fuscous, anal tuft ochreous-white. Legs ochreous-white, anterior pair infuscated. Forewings lanceolate; *metallic white, more or less infuscated, particularly on basal ⅓ of costa;* a linear spot of fuscous below fold at ⅜; a median fuscous streak from ⅔ to near apex; both these markings usually obscure or absent: cilia pale fuscous, round apex clear white. Hindwings and cilia greyish-fuscous.

Near *E. exaula* Meyr., but the conspicuous black markings of that species are absent.

Taken by Messrs. Fenwick and Watt at Waimarino, in January. Five males were sent for examination. Holotype (♂) in coll. C. C. Fenwick.

GLYPHIPTERYGIDAE.

Simaethis albifasciata n. sp.

♂ ♀. 11-12 mm. Head and thorax bronzy-brown densely sprinkled with white. Palpi ringed with bronzy-brown and white alternately, second segment slightly tufted beneath. Antennae bronzy-brown annulated with white, *ciliations in* ♂ 4. Abdomen bronzy-brown, segmental divisions white. Legs pale brown mixed with white, anterior tarsi annulated with white. Forewings, costa slightly arched, apex rounded, termen straight, oblique; bronzy-brown mixed with blackish; a patch of white scales at base above middle; *a broad irregular band of white scales at* ⅓, a small white spot on costa beyond middle giving rise to a very irregular line composed of violet and blue metallic scales mixed with white; this line is strongly excurved at middle and is there preceded by a similar but short line in disc; a broad white subterminal band of white scales, followed on the median portion by a line of metallic scales; a terminal line of white scales more or less interrupted at middle: cilia bronzy-brown with a thick black basal line and white tips at middle and tornus. In female there is a greater admixture of white. Hindwings pale bronzy-brown; a straight white fascia from termen before tornus directed towards ⅔ of costa, and reaching half-way across wing; a fragmentary white fascia between this and termen: cilia as in forewings but paler and white tips inconspicuous.

Structurally only comparable with *S. marmarea* Meyr., but the prominent white subterminal band is sufficient to distinguish it, and there are several other differences.

A male and female taken in forest on the Mount Arthur Tableland track in December at an elevation of 4,000 ft.; and a female secured at Gouland Downs in February. Mr. C. C. Fenwick has a specimen captured on Mount Ruapehu in January. Holotype (♂) and allotype (♀) in coll. Cawthron Institute.

TINEIDAE.

Lindera tessallatella Blanch., *Hist. fis. y pol. d Chile, Zool.*, vol. 7, p. 105, 1852.

This well-known Australian species has now to be recorded from New Zealand. Five specimens have been taken in Nelson on dates ranging from December to June. In the Dominion Museum collection is an example which came from the collection of the late Mr. Norris, but it has no label, and no data are available. Mr. J. G. Myers has reared the species from a larva found in old sacking and rubbish at Aramoho, the moth emerging on 26th October.

In general appearance this species is very similar to the Oecophorid *Borkhausenia pseudospretella* Stt., and no doubt specimens have been frequently passed over for that species. As the publication in which Blanchard's description appeared is not easy of access to New Zealand students I here give a short description of the species.

♂ ♀. 16–34 mm. Head, palpi, and thorax ochreous. Antennae ochreous, obscurely annulated with fuscous. Abdomen and legs pale ochreous. Forewings, costa moderately and evenly arched, apex broadly rounded, termen very oblique; pale ochreous, densely covered with fuscous dots and strigulae; round apical half of costa and on dorsum the dots are larger; a prominent large spot on fold at ½: cilia ochreous mixed with fuscous. Hindwings and cilia dull fuscous.

Mallobathra strigulata n. p.

♂ 15 17 mm. Head dark brown, sometimes ochreous-tinged. Antennae ochreous, blotched with fuscous, ciliations in ♂ 2½. Thorax dark bronzy-brown. Abdomen dark brown. Legs brown, anterior tarsi annulated with ochreous. Forewings, costa evenly arched, apex rounded, termen obliquely rounded, *dark bronzy-brown with numerous transverse waved ochreous bands, inseparable on apical half of wing;* near base, especially on dorsal part of wing, some violet metallic scales; on dorsum at middle the bronzy-brown colouring forms a dark semicircular spot margined before and behind by a clearer area of ochreous: cilia bronzy-brown mixed with ochreous. Hindwings and cilia dark fuscous.

In general appearance near *M. crataea* Meyr., but nearly twice as large and with clearer markings.

Nelson, in forest at 2,500 ft. Not uncommon in December. Holotype (♂) and a series of paratypes in coll. Cawthron Institute.

Mallobathra fenwicki n. sp.

♂. 14 mm. Head dark brown, ochreous-tinged. Antennae dark brown, obscurely annulated with ochreous, ciliations in ♂ 3. Thorax dark purplish-brown. Abdomen rich dark brown. Legs brown, tarsi annulated with ochreous. Forewings, costa evenly arched, apex broadly rounded, termen oblique; dark shining purplish-brown with slight ochreous admixture; an obscure ochreous mark on termen before ½ and a more prominent triangular ochreous patch before tornus: cilia concolorous with wing. Hindwings and cilia dark purplish-fuscous but less bright than forewings.

Close to *M. homolapa* Meyr., but differing chiefly in the pronounced purplish sheen.

Mount Ruapehu, in January. Two or three examples taken by Messrs. Fenwick and Watt. Holotype (♂) in coll. C. C. Fenwick.

The Tibial Strigil of the Lepidoptera.

By ALFRED PHILPOTT, F.E.S., Assistant Entomologist, Cawthron Institute, Nelson.

[*Read before the Nelson Institute, 13th September, 1922, received by Editor, 21st October, 1922; issued separately, 6th June, 1924.*]

Plate 18.

THE antennae of insects, being frequently clothed with hair, and often bearing dentate or pectinate processes, stand in need of some method by which they can be kept free from dust, particles of food, and other matter, which if not removed would sooner or later interfere with the carrying-out of their functions. Few insects have entirely naked legs; in almost all cases the limbs are clothed with spines, hair, setae, or scales, such armature acting as combing or brushing organs for the head, wings, and other parts of the body. For the treatment of the antennae, however, special structures have been evolved in several groups. In the ants, for instance, the apical spur of the anterior tibia and the base of the opposing first tarsal segment are armed with a row of spines, the antennae being drawn through them; in the honey-bee the first tarsal segment has, near its base, a transverse rounded notch which fulfils the same purpose. In the Coleoptera the members of the Carabidae have the anterior tarsi armed beneath with a complicated series of combs and brushes. But in the Lepidoptera alone does an antenna-cleaning apparatus appear as an ordinal character.

In the literature at my disposal I have been unable to discover any detailed description of the lepidopterous strigil. Meyrick (*Handbook of British Lepidoptera*, p. 4) says, "The anterior tibia [in Lepidoptera] is . . . furnished beneath with a median spine-like process," but does not make further reference to the structure. Sharp (*Cambridge Natural History*, vol. 6, p. 314) states that "the front tibia [in the Lepidoptera] usually possesses on its inner aspect a peculiar movable pad; this seems in some cases to be a combing-organ; it also often acts as a cover to peculiar scales." J. B. Smith (Revision of the Deltoid Moths, *Bulletin of the United States National Museum*, No. 48) describes at some length the very peculiar modifications of the legs in that group of Lepidoptera, but I have not had an opportunity of examining any species dealt with by him.

Though in this paper I treat these structures as strigils or combs for the antennae, it must be remembered that their actual use in such a connection has not been observed;* it is because the modification of the antennae and the tibial structure seem to be correlated that I adopt this provisional view of the function of the latter. It will be found that, in general, those species with the most "plumose" antennae have the most highly developed strigils; further, when the male has strongly pectinated antennae and the female simple ones, or nearly so, the former will be found to have a well-developed tibial structure, while that of the latter may be barely half the size. It may also be observed that the position and shape of the organ, together with the modification of the tibia, are such as would be suitable for the function indicated.

Except in certain instances, to be referred to, it does not appear that the study of the tibial strigil will prove of much value to the systematist.

* Since the above was written the act of passing the antennae through the strigils has several times been observed. It is not uncommon to see moths which have been put in the cyanide killing-bottle, as soon as the effects of the fumes begin to be felt, commence to comb their antennae rapidly with the strigils.

Throughout the Heteroneura, with such exceptions as the deltoid group and a few others, the strigil remains very much the same, varying only in being a little broader or narrower, more flattened or more rounded, curved or straight. Between the strigil of the Heteroneura and that of the Homoneura, however, the difference is considerable, while the difference between the families of the Homoneura is as great as that between the suborders.

In order to ascertain if any homologous structure was present in related orders, the Trichoptera and Mecoptera were examined. In the Trichoptera, species of the genera *Rhyacophila*, *Psilochorema*, *Hydrobiosis*, *Hydropsyche*, *Polyplectropus*, *Triplectides*, *Notanatolica*, *Oecetis*, *Philanisus*, *Philorheithrus*, *Pycnocentria*, *Olinga*, and *Oeconesus*; and, in the Mecoptera, *Choristella Nannachorista*, *Harpobittacus*, *Taeniochorista*, *Bittacus*, *Choristella*, and *Merope*, have all yielded negative results, and it seems therefore reasonably certain that the tibial strigil in the Lepidoptera is peculiar to that order.

The families of the Lepidoptera, as far as I have been able to examine them, will now be considered in order, and the modifications of the cleaning-apparatus described.

Suborder HOMONEURA.

Micropterygidae.

Of this, the most primitive family of the Lepidoptera, I have examined *Sabatinca* and *Micropteryx* only. The strigil in these genera (fig. 1) is a simple leaf-shaped structure, lying, both transversely and longitudinally, convexly to the tibia (fig. 2). It is covered with hair on both surfaces, but that on the inner surface is longer, and directed chiefly towards the outer fissure, forming there a marginal fringe. At its attachment to the tibia the strigil is much narrowed, and connects to a circular base by means of a thin membrane which allows of free movement (fig. 3). This method of basal connection seems to point strongly to the strigil being a modified spur. Presumably, after development into a strigil, the structure moved basad or distad in sympathy with the tibial modification or other conditions as the different forms evolved. The base of the strigil is about the middle of the tibia, and its apex rather less than a quarter from the tibial apex. Except for being somewhat swollen round the base of the strigil, the tibia itself is not modified; there is not the flattening beneath, nor the formation of a groove, as occurs in the higher groups.

Mnesarchaeidae.

In *Mnesarchaea* the strigil is very much reduced, being only about four-fifths as long as the tibia is broad (fig. 4). It is clothed with scales similar to those on the tibia itself, and no hair is present. The reduction of the organ in this genus is apparently correlated with the type of antenna, this being filiform and scaled, with a few minute hairs. In *Sabatinca* the better-developed strigil is accompanied by submoniliform antennae which are thickly covered with hair.

Hepialidae.

In the Hepialidae the strigil is not homologous with the structure so far described; it is an outgrowth from the tibial wall instead of a modified spur. The Hepialidae are without tibial spurs, and it seems probable that they were never provided with the strigil as it exists in other Lepidoptera, but evolved a different organ to carry out the same function. At or near the base of and beneath the tibia there is a flap-like structure, covering the lower surface and extending usually about half-way along the segment (fig. 5). There is no indication of a hinge at the base, the strigil passing

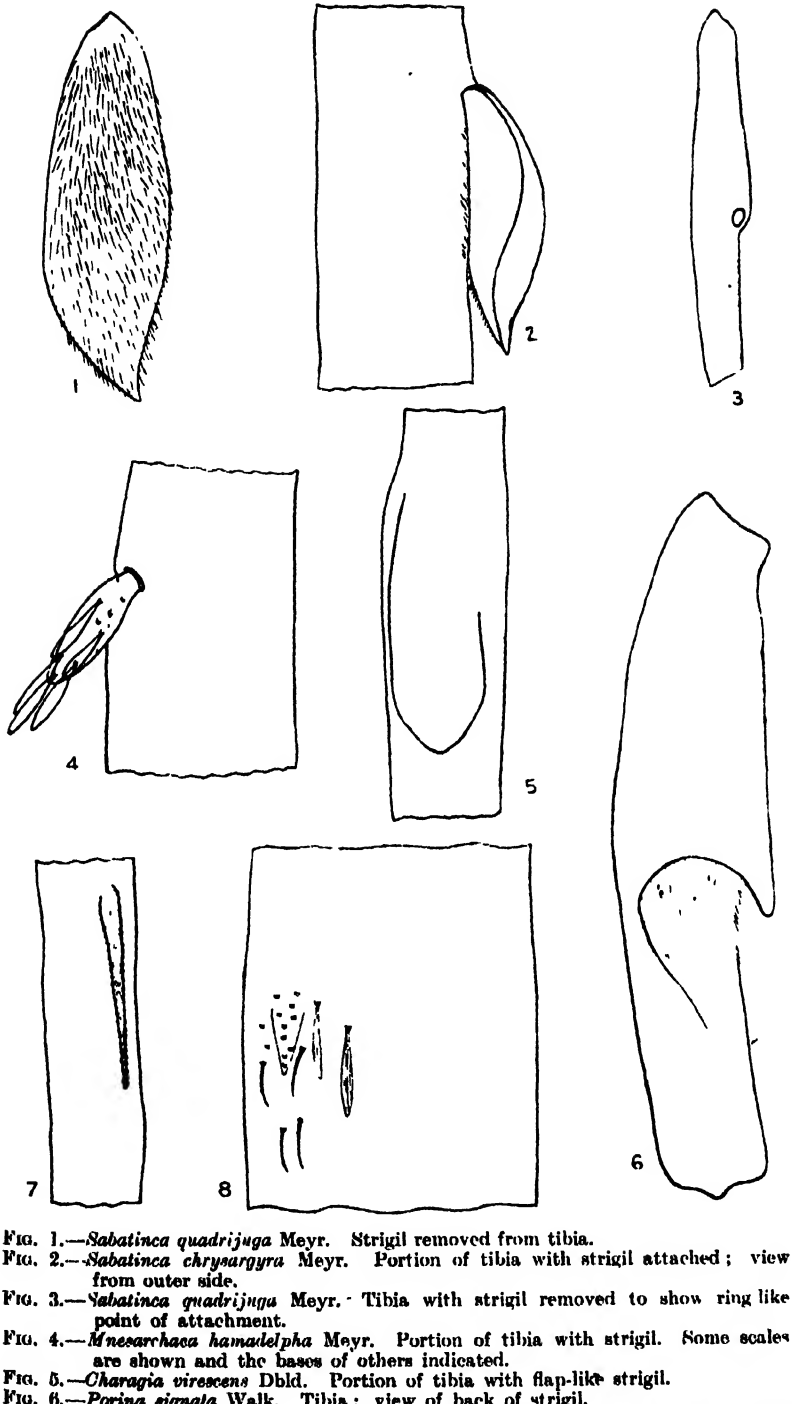


FIG. 1.—*Sabatinca quadrijuga* Meyr. Strigil removed from tibia.
FIG. 2.—*Sabatinca chrysargyra* Meyr. Portion of tibia with strigil attached; view from outer side.
FIG. 3.—*Sabatinca quadrijuga* Meyr. Tibia with strigil removed to show ring like point of attachment.
FIG. 4.—*Mnesarchaea hamadelpha* Meyr. Portion of tibia with strigil. Some scales are shown and the bases of others indicated.
FIG. 5.—*Charagia virescens* Dbld. Portion of tibia with flap-like strigil.
FIG. 6.—*Porina signata* Walk. Tibia: view of back of strigil.
FIG. 7.—*Oncopera mitocera* Turn. Portion of tibia, showing reduced spine-like strigil.
FIG. 8.—*Fraus* sp. Portion of tibia, showing vestigial strigil with spines and scales

into the tibia without any modification. The origin of the organ, in this family, was probably a simple notch or ridge on the tibia; this developed into a fold, and thence into a flap, after which, in some instances, it narrowed into a spur-like form. The walls of the strigil are not fused, and can be separated without difficulty. In *Porina* the strigil is strongly concave to the tibia, forming a rounded channel for the reception of the antenna (Plate 18, fig. 3). The outer sinus is not usually produced far back towards the base; in many instances the outer apical margin is broadly excurved, and joins the tibia forward of the apical point (fig. 6). *Porina dinodes* Meyr. differs from most of the other members of the genus in having the strigil lying closer to the tibia, thus forming a sinus which reaches backwards for nearly half the length of the structure. *Perissectis* is similar to *Porina*; *Charagia* and *Trictena* have very simple strigils, merely flaps standing out very slightly from the tibia and quite hidden in the long hair of the limb. The huge Hepialid, *Leto staceyi*, is one of the few species of moth in which I have failed to find a strigil of any sort. The antennae of this species are very short and but slightly hairy, and both tibia and tarsi bear thick spreading tufts of hair on each side; probably these brush-like devices have superseded the strigil as a cleaning-apparatus. In *Fraus croceus* Luc. the strigil has become somewhat spur-like, owing to the outer fissure being carried back as far as the inner, combined with a narrowing of the organ. In *Oncopera* this narrowing is carried to an extreme point, the strigil being reduced to the form of a stout spine. This process, which is covered with minute hairs, springs from about the middle of the tibia and extends to four-fifths (fig. 7). An undetermined species of *Fraus* from Australia is interesting as showing marked sexual differences in the strigil. In the male the organ is of the usual generic type, though rather small, while in the female it is reduced to a mere vestige (fig. 8). The tibia, beneath the strigil, is covered with curved macrotrichia, and these are still present forward of the diminished female organ. It seems probable that these hooks form the essential part of the cleaning-apparatus, that the strigil is now more or less functionless, and is undergoing reduction accordingly.

Suborder HETERONEURA.

In the Heteroneura the typical strigil is a rather flat organ, something like a longitudinally folded leaf. In the lower groups this fold is not central, leaving a considerable portion of the inner part single, but in the higher groups the folding is often complete, and the strigil tends to become irregularly tubular. The structure is more or less convex to the limb, and is clothed on the inner side with short dense hair. It is situated on the lower surface of the tibia, and usually takes an outwardly-oblique course. In most species it occupies the central third of the limb, but may arise from near the base and extend to the apex; in the Pterophoridae, where the tibia is much elongated, the strigil has moved distad to an apical position. The tibia itself is usually flattened beneath, and the hair on that part of its surface covered by the strigil is frequently lengthened and directed obliquely outwards so as to be opposed to the antenna when it is being drawn through. On the outer side of the tibia there is usually a more or less dense brush of hair; this covers the outer fissure of the strigil, and apparently acts as part of the cleaning-apparatus. Beneath the strigil the tibia is often hollowed out so as to form a groove for the reception of the antenna.

TINEOIDEA, TORTRICOIDEA, AND PYRALOIDEA.

These three superfamilies require little comment. The strigil is of the type described under the heading of the suborder, and is remarkably uniform (figs. 9, 10, 11, 12, 13).

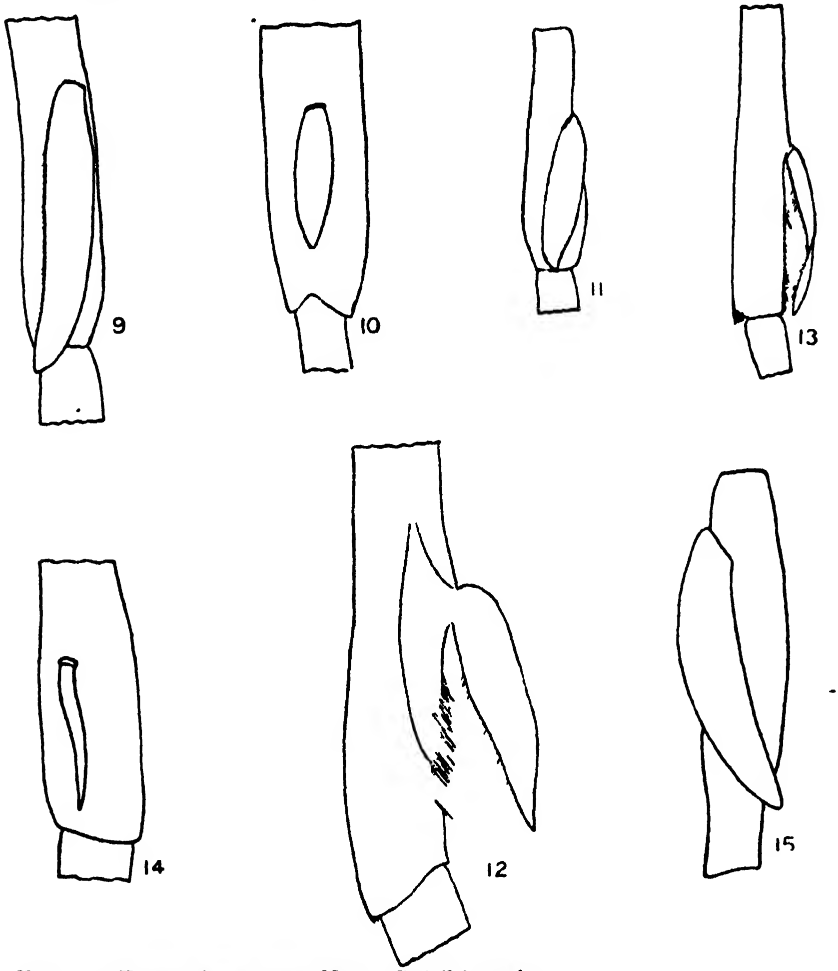


FIG. 9.—*Xysmatodoma saxosa* Meyr. Strigil in male.
FIG. 10.—*Xysmatodoma saxosa* Meyr. Strigil in female.
FIG. 11.—*Crosidosema plebeiana* Zell.
FIG. 12.—*Crambus crenaeus* Meyr. Strigil folded back to show concavity beneath.
FIG. 13.—*Alucita monospilalis* Walk. Tibia, viewed from outer fissure of strigil.
FIG. 14.—*Synemon hesperoides* Feld.
FIG. 15.—*Entometa fervius* Walk.

CASTNIOIDEA.

CASTNIDAE.

In this family only two or three species of *Synemon* have been available for examination. In these the strigil is folded completely round and fused, forming a hollow spur. The structure has the appearance of a much reduced organ, and it is probable that the smoothly jointed and closely scaled antennae are not difficult to keep clean (fig. 14).

ZYGAENOIDEA.

Zygaenidae.

In the small moths of the genus *Pollanisus*, the only species investigated, no strigil is present.

Limacodidae.

Neither sex possesses a strigil. The antennae are comparatively short, but are usually bipectinated in the male, frequently only on the basal portion All the tibiae, and also the first tarsal segments, are thickly fringed with long hair-scales; on the anterior pair of legs these scale-brushes may carry out the functions of the strigil.

LASIOCAMPOIDEA.

Lasiocampidae.

The genera *Entometa* and *Porela* have a strong strigil springing from a little below the base of the tibia and extending almost to the apex. It is slightly flattened, curved, and spur-like (fig. 15).

NOCTUOIDEA.

Liparidae.

The Liparidae have the strigil rising above the middle of the tibia. Frequently it springs from just below the base, as in *Laelia*, *Notoloupus*, and *Porthesia*. In some genera for instance, *Argina* and *Asota* - it is rather short and broad (fig. 16), but in *Porthesia* and its allies the organ is as long as the tibia itself. The sexual difference in this group is also very striking. In the females of *Laelia* and *Porthesia* the strigil is reduced to an apparently functionless vestige, a weak and thin appendage covered with fine hairs (figs. 17, 18). In *Notoloupus australis* Walk. the female is apterous and has lost all trace of the strigil. It need hardly be said that these sexual differences in the strigil are correlated with the condition of the antennae, those of the males being strongly pectinated, while those of the females are shortly pectinated or simple. The male of *Laelia obsoleta* Fabr. has the longest antennal pectinations of any species of the family which I have examined, and the strigil is proportionately longer than in any other.

Noctuidae.

In the Hypeninae and Plusiinae the strigil is usually rather short and broad, the organ springing from a little below the base of the tibia (fig. 19). The antennae in these groups are generally of the simple type, but in the somewhat aberrant *Rhapsa scotosialis* Walk. the antennae of the male are strongly bipectinated a condition accompanied by a corresponding development of the strigil, which is almost as long as the tibia. In the group of small forms represented by *Eublemma*, *Araeoptera*, and other genera the strigil is of normal shape and size, but in *Tarache nivipicta* Butl. the organ has moved distad to the middle of the tibia and is broader than usual, the tibia being also broadened and flattened to accommodate it (fig. 20). In the Melanchrinae a different type of antennal armature is met with. The segments are frequently subdentate, or serrate, and are almost always either ciliated or bear short stiff pectinations. Apparently in order to meet these modifications, the strigil in this group has assumed a special form. The outer margin, instead of being free from base to apex, is attached

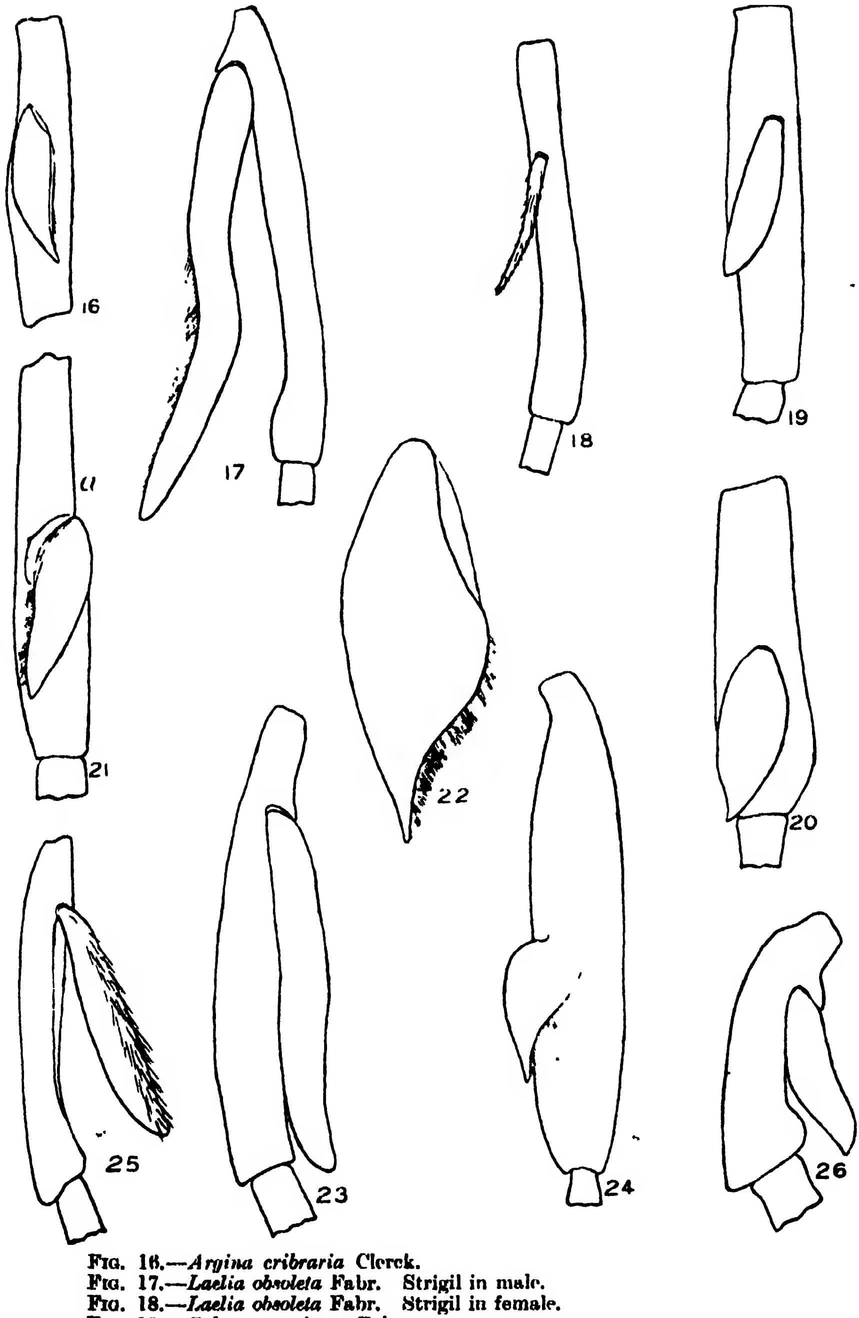


FIG. 16.—*Argina cribraria* Clerck.
FIG. 17.—*Laelia obsoleta* Fabr. Strigil in male.
FIG. 18.—*Laelia obsoleta* Fabr. Strigil in female.
FIG. 19.—*Calpe emarginata* Fabr.
FIG. 20.—*Tarache nivipicta* Butl.
FIG. 21.—*Melanchra agorastis* Meyr. To show (*a*) attaching membrane.
FIG. 22.—*Persectania ewingii* Westw. Detached strigil.
FIG. 23.—*Ichneutica ceraunias* Meyr.
FIG. 24.—*Schistophleps albida* Walk.
FIG. 25.—*Ardices curvata* Don.
FIG. 26.—*Melacrias erichrysa* Meyr.

by a membrane for a third or more of its upper portion to the tibia (figs. 21, 22). The lower part is armed with the usual fringe of hairs, but near its centre it is broadly and deeply convex. The tibia is somewhat flattened, and bears an oblique groove which passes beneath the comb, forming with the convexity of the latter a covered channel through which the antenna can be drawn. Fitting into the convexity of the strigil is a dense bunch of hairs, the whole forming a cleaning-apparatus with comb above and brush below That this type of strigil is correlated with the usual type of antennal armature in the Melanchrinae seems still more probable when the genus *Ichneutica* is examined (fig. 23). Here the antennal segments are more regular, and the armature consists of strong bipectination. Not only is the strigil greatly enlarged, being about four-fifths of the length of the tibia, but its outer margin is free right to the base. and there is no concavity similar to that generally found in the group.

Arctiidae.

In the Arctiidae the antennae are usually small, and have little armature. The strigil, which is usually not highly developed, shows in some forms, as *Schistophleps* (fig. 24), the same extension of the attaching membrane as in the Melanchrinae. *Comarchis* and *Celama* also exhibit this character, though in a less degree. *Ardices* possesses an unusual type of strigil for this family, it being long, free throughout the entire length of the lower fissure, and covered outwardly with dense hair-scales (fig. 25). *Metacrias* also displays a peculiar strigil. The tibia in this genus is very short; it is also somewhat curved and hollowed out beneath. In this convexity, its base being deeply sunk in the limb, lies a broad naked strigil (fig. 26).

Syntomidae.

The Syntomidae offer no unusual strigilar features, the organ being rather small, centrally folded, and broadly lanceolate, with the usual fringe of hairs on the outer margin.

NOTODONTOIDEA.

Notodontidae.

In *Neola semiaurata* Walk. the strigil in the male is strongly concave to the tibia and follows a somewhat spiral course. In *Epicoma tristis* Lewin the organ is also concave, but has no spiral twist (fig. 27). In the females of both these species the strigil is absent, as it is also in the very peculiar *Ochrogaster contraria* Walk.

Sphingidae.

The hawkmoths have a well-developed strigil occupying the middle third or more of the tibia. It is concave to the limb, centrally folded, and bears a fringe of stiff spines on the margin of its inner fold (Plate 18, fig. 2). Though the edges meet, they are not fused except towards the apex. The organ is deeply set in the tibia at the base, and is almost entirely exposed (fig. 28). In *Metamimas australasiae* Don., however, the fringe of hair which in all species occurs on the outer side of the tibia is curved round, the lengthened upper part of it acting apparently as a spring to keep pressure on the strigil, and the lower part forming a rounded channel to receive the antenna (Plate 18, fig. 1).

GEOMETROIDEA.

Throughout this superfamily the strigil shows little variation. It usually occupies from one-half to one-third of the tibia apically. It is generally only partially folded, so that the lower fringed part can be seen

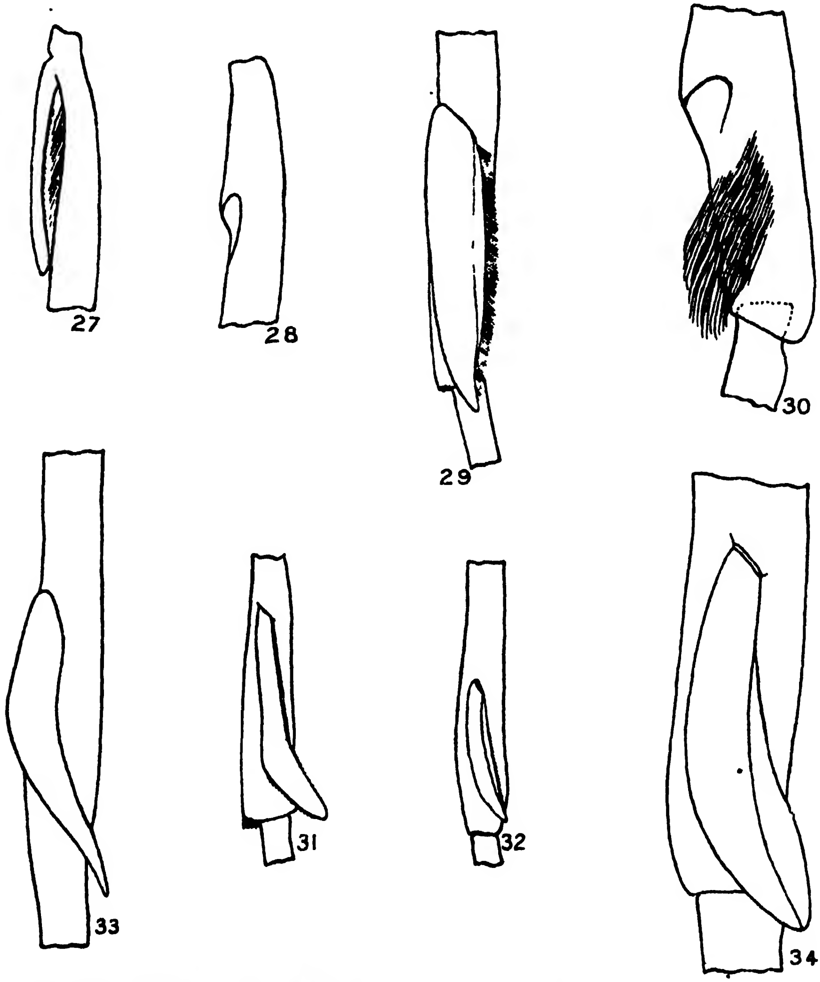


FIG. 27.—*Epicoma tristis* Lewin.
FIG. 28.—*Cephanodes janus* Misken. Portion of tibia with strigil removed.
FIG. 29.—*Venusia undosata* Feld.
FIG. 30.—*Tatosoma lestevata* Walk. Portion of tibia with strigil removed to show dense tuft of hair beneath.
FIG. 31.—*Declana junctilinea* Walk. Strigil in male.
FIG. 32.—*Declana junctilinea* Walk. Strigil in female.
FIG. 33.—*Papilio macleayanus* Leach.
FIG. 34.—*Signeta flammeata* Butl.

projecting (fig. 29). The brush on the tibia is long and dense (fig. 30). Many of the species provide excellent examples of the correlation between antennal armature and strigilar development. In those forms in which the antennae of the male are bipectinated while those of the female are

simple the strigil is invariably found to be much reduced in the latter sex. For instance, in the male of *Venusia undosata* Feld. (see fig. 29), which has strongly bipectinated antennae, the strigil is more than half the length of the tibia; but in the female of the species, the antennae of which are simple, the organ is only one-quarter the length. The same sexual difference in antennae and strigil occurs in *Xanthorhoe*, *Notoreas*, and *Selidosema*, but in *Dasyuris*, where the antennae are simple in both sexes, there is practically no difference in the size or condition of the strigil. In *Declana* most of the species have strongly pectinated antennae in the male and less strongly pectinated or simple antennae in the female. Figures of the tibiae in both sexes of *Declana junctilinea* Walk. under equal magnification are given, in order to show not only the difference in size, but the strong bend or angle of the apical portion in the male (figs. 31, 32).

URANIOIDEA.

URANIIDAE.

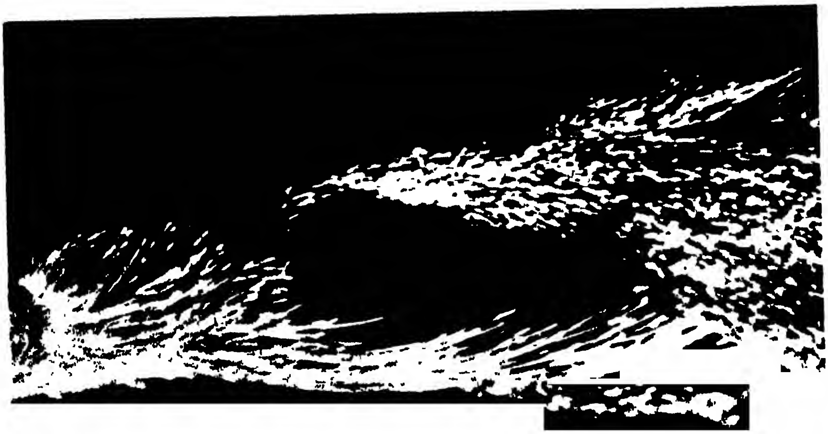
The striking day-flying North Australian moth *Nyctalemon orontes* Linn., so like a butterfly superficially, has a strigil resembling that of *Papilio*, but less folded and shorter in proportion.

PAPILIONOIDEA.

In the butterflies many of the families have more or less reduced anterior legs, and in such families the strigil has disappeared. In those families in which the forelegs are normally developed, however, a strigil is present. It is usually rather long and narrow, folded completely round, and partially fused (fig. 33). In the Hesperidae the strigil is almost hidden in a tuft of hair-scales. It is folded almost into a tube, though the edges are not fused. It lies strongly convex to the limb, and if viewed from the right angle an aperture may be observed between the two, with the hair on both surfaces directed towards the middle line (fig 34).

In conclusion, it may be pointed out that many of the families of the Lepidoptera have not been examined, but it does not seem probable that the investigation of these will materially affect the conclusions arrived at, which may be summarized as follows: In the Lepidoptera, with comparatively few exceptions, a strigil or comb for cleaning the antennae is found on the anterior tibiae This strigil is a modified spur which has become flattened and covered with hair beneath. In some of the most specialized forms this flat leaf-like organ has been completely folded round, the margins meeting and becoming fused so as again to take the form of a hollow spur. In one group, the Hepialidae, the strigil does not seem to have been derived from a spur, but to have originated as an outgrowth of the tibial wall. Almost invariably the development of the strigil is found to be correlated with the condition and armature of the antennae, whether such condition be sexual or systematic.

I desire to express my thanks to Dr. R. J. Tillyard, Chief of the Biological Department, Cawthron Institute, for reading the text, and for much encouragement and advice during the carrying-out of the investigation; also to Mr. W. C. Davies, Curator of the Institute, for the excellent photographic plate.



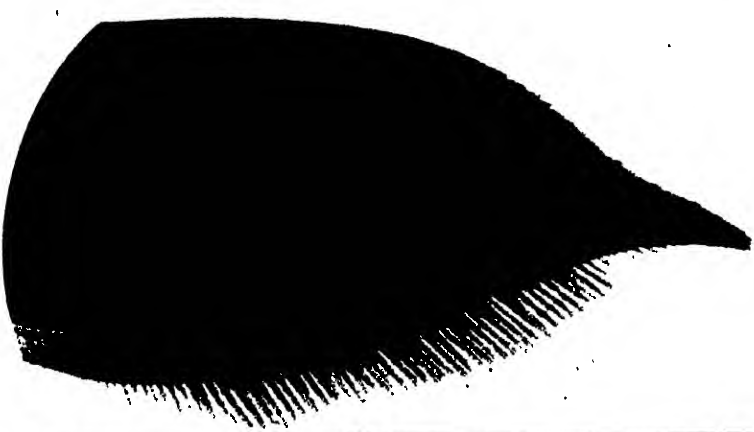


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Fig. 1.—Portion of tibia of *Metamimas australasiae* Don. with strigil *in situ*.
Fig. 2.—Apical portion of the strigil of *Sphinx convolvuli* L., to show fringe of spines.
Fig. 3.—Tibia of *Porina jocosa* Meyr. with strigil *in situ*.

Report on some Hydroids from the New Zealand Coast, with Notes on New Zealand Hydroida generally, supplementing Farquhar's List.

By W. M. BALE, F.R.M.S.

Communicated by Dr. Chas. Chilton.

[*Read before the Philosophical Institute of Canterbury, 2nd August, 1922; received by Editor, 31st December, 1922; issued separately, 12th June, 1924.*]

1. INTRODUCTION.

THE Hydroida dealt with in the present paper are, for the most part, included in a collection forwarded by Professor Chilton from the Canterbury College, Christchurch, to Mr. E. A. Briggs, of the Australian Museum, Sydney, for examination and report.* Mr. Briggs commenced the work, but, finding that stress of official duties was likely to prolong it unduly, he suggested that I should undertake the task, which I have accordingly done. I have also included descriptions of several other New Zealand species hitherto imperfectly known, or not identifiable from the original accounts.

I have to thank Professor W. B. Benham, of the University Museum, Dunedin, for valuable assistance in sending me portions of type specimens of some of Hutton's and Coughtrey's species, preserved in the Museum, which enable me to identify some of those species previously unrecognized.

My thanks are also due to the Trustees of the British Museum for examples of some of Allman's New Zealand species, as well as for one of Gray's not hitherto identified since its description in 1843. This species, as well as several of Allman's which have been wrongly associated with other forms, will now, I trust, be rendered identifiable. I have specially to thank Captain Totton, of the British Museum, for much trouble taken by him in furnishing me with information regarding the New Zealand species in the Museum, and forwarding specimens.

2. LITERATURE OF THE NEW ZEALAND HYDROIDA.

The first published list of New Zealand Hydroida was that by Dr. J. E. Gray, in Dieffenbach's *New Zealand*, 1843, in which were described four species collected by Dr. Sinclair and one by Sir Joseph Banks.

Captain Hutton's paper in *Trans. N.Z. Inst.* for 1872 included several new species, with a number of those previously known; in some of the latter, however, the identifications have proved mistaken

Dr. Millen Coughtrey, in his papers in *Trans. N.Z. Inst.* for 1874 and 1875, and one in the *Annals and Magazine of Natural History* for 1876, added considerably to what was already known regarding the New Zealand species, and included some new ones, also furnishing, for the first time, figures of the forms described. Of the few Plumularians mentioned,

* The collection has been deposited in the Canterbury Museum, Christchurch, New Zealand.—C. C.

however, the figures and descriptions have not proved sufficient to enable observers to discriminate between nearly allied forms.

For the next twenty years no special account of New Zealand species appeared, either in the colony or elsewhere, but a number of new species were included in Allman's papers in the *Journal of the Linnean Society* of 1876 and 1885, and in the "Challenger" Reports; also in the works of Kirchenpauer, Thompson, von Lendenfeld, Marktanner-Turneretscher, and others.

All these are enumerated in Farquhar's "List of New Zealand Hydroida," which was published in *Trans. N.Z. Inst.*, vol. 28, p. 459, 1896, and which is the only complete list of New Zealand species up to that date. More recent publications are Hilgendorf's "On the Hydroids of the Neighbourhood of Dunedin," in *Trans. N.Z. Inst.*, 1897, and a report on a collection of New Zealand hydroids in the *Zoologischen Jahrbuchern*, 1901, by Dr. Cl. Hartlaub.

3. Nomenclature.

Since the publication of Farquhar's list there have been many changes of nomenclature, especially as a result of Levinsen's researches among the Sertularians. For example, species which were formerly regarded as typical *Thuiariae* are now referred to *Sertularella*, others which were ranked under *Sertularia* have been relegated to *Thuiaria*, and so on. Species which for these and other reasons have had their names changed are comprised in the following list, in which Farquhar's names appear in the first column, and the names to which the various species are assigned in the present paper in the second.

Names in Farquhar's List.	Names in this Paper.
Tubularia attennoides Coughtrey ..	*Tubularia attenuoides* Coughtrey.
Coryne tenella Farquhar	*Syncoryne tenella* (Farquhar).
Campanularia caliculata Hincks ..	*Orthopyxis caliculata* (Hincks).
Campanularia caliculata var. *makrogona* v. Lendenfeld	*Orthopyxis macrogona* (v. Lend.).
Campanularia bilabiata Coughtrey ..	*Silicularia bilabiata* (Coughtrey).
Hebella scandens (Bale)	*Hebella calcarata* (L. Agassiz).
Halecium delicatula Coughtrey	*Halecium delicatulum* Coughtrey.
Halecium parvulum Bale	*Halecium flexile* Allman.
Sertularia elongata Lamouroux	*Stereotheca elongata* (Lamouroux).
Sertularia crinis Allman	*Sertularia fasciculata* (Kirchenpauer).
Sertularia ramulosa Coughtrey	*Sertularia fasciculata* (Kirchenpauer).
Sertularia huttoni Marktanner-Turneretscher	*Stereotheca huttoni* (Marktanner-Turneretscher).
Sertularella capillaris Allman	*Sertularella johnstoni* (Gray).
Sertularella polyzonias (Linné)	*Sertularella simplex* (Hutton).
Sertularella episcopus Allman	*Sertularia episcopus* (Allman).
Thuiaria zelandica Gray	*Stereotheca zelandica* (Gray).
Thuiaria monilifera Hutton	*Selaginopsis monilifera* (Hutton).
Thuiaria subarticulata Coughtrey ..	*Sertularella subarticulata* (Coughtrey).
Thuiaria quadridens Bale	*Sertularella quadridens* (Bale).
Desmoscyphus buskii Allman	*Thuiaria buski* (Allman).
Hydrallmania bicalycula Coughtrey ..	*Thuiaria bicalycula* (Coughtrey).
Synthecium ramosum Allman	*Synthecium elegans* Allman.
Synthecium campylocarpum Allman ..	*Synthecium orthogonium* (Busk).
Plumularia campanula Busk	*Schizotricha campanula* (Busk).
Plumularia turgida Bale	*Plumularia setacea* (Ellis).
Plumularia multinoda Allman	*Plumularia setacea* (Ellis).
Aglaophenia banksii (Gray)	*Hemicarpus banksi* (Gray).
Aglaophenia formosa (Busk)	*Thecocarpus formosus* (Busk).
Aglaophenia pennatula? Coughtrey ..	*Aglaophenia huttoni* Kirchenpauer.

4. ADDITIONS TO THE SPECIES SINCE FARQUHAR'S LIST.

In Hilgendorf's paper of 1897 are included six species said to be new to New Zealand. They are as follows:

Tubiclava fruticosa Allman. (The identification with Allman's species is doubtful, and the form does not appear different from *T. rubra* Farquhar.)
Hemitheca intermedia n. sp.
Obelia nigrocaulus n. sp.
Calycella parkeri n. sp. (This is not at all like a *Calycella*, but is a typical *Gonothyraea*, very probably *G. hyalina* Hincks.—*Vide G. Parkeri.*)
Hypanthea asymmetrica n. sp. (The same as *Eucopella campanularia* v. Lendenfeld, now referred to *Silicularia.*)
Aglaophenia filicula Allman. (Identification very doubtful.)

Hartlaub, in his paper of 1901, adds the following:—

Syncoryne sp.
Perigonimus sp.
Clytia johnstoni (Alder).
Eucopella crenata n. sp. (Previously figured, but not named, by Coughtrey. See *Orthopyxis crenata.*)
Thyroscyphus tridentatus (Bale). (= *T. simplex* (Lamouroux).)
Sertularella tenella (Alder). (One of the forms included by Coughtrey under *S. simplex*, but afterwards named by him *S. robusta*, q.v. Not *S. tenella ?*)
Sertularella solidula Bale. (Not *S. solidula;* see *S. crassiuscula.*)
Sertularella fusiformis Hincks var. *nana.* (Is *S. simplex* Hutton.)

In a paper in *Trans. N.Z. Inst.*, vol. 47, p. 146, 1915, Professor H. B. Kirk describes a new genus and species, *Ascidioclava parasitica.*

The hydroids which in the present paper are recorded as new to the New Zealand region are the following:—

Syncoryne sp. Bale.
Syncoryne eximia Allman.
Obelia nodosa n. sp.
Obelia coughtreyi n. sp.
Campanulina humilis n. sp.
Thuiaria farquhari n. sp.
Sertularella columnaria Briggs.
Sertularella crassiuscula n. sp.
Sertularella edentula n. sp.
Plumularia setacea (Ellis) var. *opima* n. var.
Plumularia wattsi Bale.
Thecocaulus heterogona n. sp.
Aglaophenia plumosa Bale.
Thecocarpus chiltoni n. sp.
Halicornaria rostrata n. sp.

The references prefixed to the various descriptions are not exhaustive. In a number of cases, where no change has occurred in the nomenclature, I have commenced with a reference to Farquhar's list, where the earlier synonymy will be found. In other cases I have referred for the synonymy to more recent publications, where they are easily procurable, like the "Endeavour" Reports, &c.

5. DESCRIPTIONS OF THE SPECIES.

Fam. ATRACTYLIDAE.

Perigonimus sp. Hartlaub.

Hartlaub, 1901, p. 363.

Hartlaub mentions a fragment of a *Perigonimus* from French Pass, but the material was insufficient for a complete diagnosis.

Fam. Bougainvillidae.

Hemitheca intermedia Hilgendorf.

Hilgendorf, 1897, p. 202.

Fam. Clavidae.

Tubiclava rubra Farquhar.

Farquhar, 1895, p. 209; 1896, p. 459.

A fragment from Sumner, containing two hydranths, much shrunken and blackened, may belong to the above species. I think it probable that the form referred by Hilgendorf to *T. fruticosa* Allman (1897, p. 201) may be the same as Farquhar's species.

Ascidioclava parasitica Kirk.

Kirk, 1915, p. 146.

Fam. Tubulariidae.

Tubularia attenuoides Coughtrey.

Tubularia attennoides Coughtrey, 1875, p. 302: Farquhar, 1896, p. 459: Hilgendorf, 1897, p. 202.

Types of this species are in the Dunedin Museum. Professor Benham points out that the correct spelling of the name is "*attenuoides*," not "*attennoides*" as hitherto printed.

Fam. Corynidae.

Syncoryne tenella (Farquhar).

Coryne tenella Farquhar, 1895, p. 208; 1896, p. 459.

A cotype of this species, among Professor Chilton's material, consists of three shoots, very slender, and not more than 8 mm. in height. The hydranths, which are badly preserved, are smaller than Farquhar's figure, the largest not being more than 1 mm. in length, with about 27 tentacles. The gonosome is not present.

Specimens from Taylor's Mistake are more robust, reaching nearly 1 in. in height, and more freely branched. Stems very dark at base, becoming gradually paler upwards, and, while proximal portions are very slender, diameter increases slightly above. Stem and branches strongly but irregularly annulated at base; there are often a few annulations on stem just above origin of branches. Terminal portions of hydrocaulus smooth, occasionally with a few faint corrugations. They do not form basal cups for hydranths.

Hydranths reach up to about 1·6 mm. in length, as figured by Farquhar, and are cylindrical, with very little tendency towards clavate form. I saw none with more than 23 tentacles, and only a few with so many. First verticil, with 4 or 5, is distinct, but there is not much regularity about the arrangement of the others. Capitula packed with numerous nematocysts, mostly from about 0·005 mm. to 0·0075 mm. in length, a few still larger.

Medusae borne on short peduncles, difficult to see when crowded among tentacles. At first oval, they become more cylindrical at maturity, with a perfectly semiglobular base, and sometimes a little expanding at mouth. Margin raised into four broad convex lobes, each with a distinct ocellus

in middle, but these are not produced into tentacles. The structure thus corresponds with that of several of the species described by Allman, and it is probable that, as in those species, the medusa does not become free. Manubrium shorter than umbrella, but very stout, occupying great part of cavity. Medusae, apparently mature, averaged about 0·35 mm. in length by about 0·25 mm. in width.

Though not more than 23 tentacles were present on any of these specimens, while *C. tenella* is said to have from 25 to 30, I do not think the difference sufficient to invalidate their reference to Farquhar's species.

Loc.- Wellington (Farquhar): Taylor's Mistake (Chilton).

Syncoryne sp.

A small *Syncoryne*, represented only by four or five specimens not exceeding 6 mm. in height, agrees pretty closely with *S. tenella* in habit, and in the character of the hydranths and the medusae, but differs in the peculiar nature of the armature. Capitula of tentacles furnished with numerous small nematocysts, very delicate, and so faintly outlined that they may be overlooked on casual examination. But besides these there are present larger ones (about 0·008 mm. in length), elliptic, and so highly refractive as to be strikingly conspicuous. Their number varies from 1 to about 15, and a few capitula may be without them.

In the stream of coenosarc are found a few of these nematocysts, with a great number of others about half their length, and still more numerous smaller oblong bodies which may possibly be yet another form of nematocyst. All these bodies have the same highly refractive character as the large nematocysts. Perhaps this may be only a peculiar condition of *S. tenella.*

Syncoryne sp. Hartlaub.

Hartlaub, 1901, p. 363.

Hartlaub mentions a species of *Syncoryne* from French Pass, but the description is incomplete, and the species cannot be identified with certainty.

Syncoryne eximia Allman.

Hincks, 1868, p. 50: Allman, 1871, p. 282.

The form which I refer, with little doubt, to the above species is represented in Professor Chilton's collection by a single mounted fragment, and I possess a similar mount, evidently the same gathering, for which I have to thank Mr. C. B. Morris, of Oamaru, the original collector.

Stems strongly annulated at base, as well as at points where branches originate, and the latter exhibit the characteristic tendency to a unilateral arrangement, while the polypiferous ramuli are mostly more or less loosely ringed throughout, and are prolonged into membranous cups of extreme tenuity (sometimes indistinct), surrounding bases of hydranths. The latter are somewhat clavate, with about 20 tentacles, the first 4 forming a regular verticil, the others scattered. Medusae ovate and pedunculate, becoming more nearly globular at maturity and assuming the typical *Sarsia* form: they are numerous and often crowded on the lower half or two-thirds of body. Hydranths reach about 1·4 mm. in length.

Loc.—Oamaru rocks (Mr. C. B. Morris).

Fam. CAMPANULARIDAE.

Obelia geniculata (Lin.).

Farquhar, 1896, p. 460: Hilgendorf, 1897, p. 204: Hartlaub, 1901, p. 362.

This cosmopolitan species has received numerous synonyms, which may be found in Nutting's work on the American Campanularidae, where the references to it occupy two and a half folio pages. Hartlaub records it from Rangitoto Island: Professor Chilton's specimen is from Oamaru rocks (Mr. C. B. Morris).

Obelia nigrocaulus Hilgendorf.

Hilgendorf, 1897, p. 203. (Dunedin.)

Obelia nodosa n. sp. (Fig. 1.)

Shoots nearly 1 in. in height, monosiphonic or slightly fascicled at base, nearly straight below, flexuous above; internodes with a few distinct rings at lower end, at top supporting a hydrotheca with ringed peduncle; a branch or gonangium, or both, springing from axil.

Hydrothecae campanulate, distal portion generally less expanding than lower, extreme margin usually everted, undulated, sometimes subregularly often simply ragged; diaphragm usually oblique.

Gonothecae on short annulated peduncles, with about three inflations more or less distinct; mouth tubular, not very wide.

Loc. Waitakerei, Auckland (Chilton).

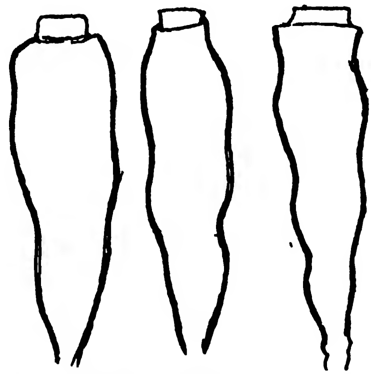


FIG. 1.—*Obelia nodosa* n. sp. × 40.

Many of the shoots are monosiphonic, but some become fascicled by the formation of stolons which originate from apertures formed at the sides of the apophyses near base, from which hydrothecae have fallen. Generally only one or two of the lowest apophyses give rise to these stolons, which run down to the hydrorhiza and are continued over it. Most of the hydrothecae have margins irregular, showing very slight traces of undulations, which are very shallow, but some show them more distinctly.

The most characteristic feature is the form of the gonangia, which have three inflations increasing in size upwards. These vary in degree, being more pronounced in some cases than in others. The tubular neck is well developed.

Obelia coughtreyi n. sp. (Fig. 2.)

Shoots about 1 in. in height, monosiphonic (?), slightly flexuous below, very strongly above; internodes with a few distinct rings at lower end, at the top supporting a hydrotheca with ringed peduncle; a branch or gonotheca, or both, springing from axil.

Hydrothecae campanulate, margin regularly undulated, but in older hydrothecae with undulations obscure, margin appearing simply ragged; diaphragm often appearing somewhat oblique.

Gonothecae on short annulated peduncles, large, wide, mouth only very little elevated.

Loc.— Taylor's Mistake (Chilton).

A more robust species than the last, the gonangia especially being much larger. They are widest at the top, and noticeable for the shallow scarcely tubular lip. There is a series of numerous annular undulations, so slight that they might easily pass unnoticed but for the fact that the minute diatoms which invest the gonangia in great numbers have in parts followed their course.

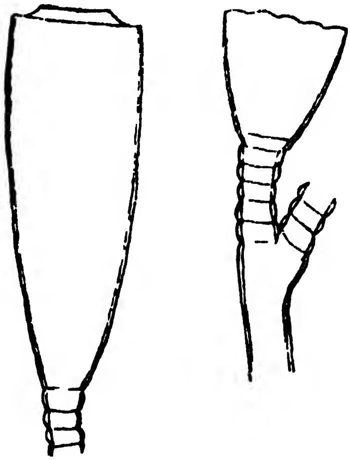


Fig. 2.- *Obelia coughtreyi* n. sp. × 40.

The hydrothecae are larger on the average than in *O. nodosa*, and usually more widened upwards; there is no doubt as to the marginal structure, which exhibits about 10 14 undulations, or shallow rounded lobes, best seen in the newer hydrothecae, as, apparently owing to their extreme delicacy, they soon become irregular and ragged.

Obelia australis v. Lendenfeld.

Farquhar, 1896, p. 460: Hartlaub, 1901, p. 367.

Hartlaub records this species from French Pass.

Gonothyraea parkeri (Hilgendorf).

Calycella parkeri Hilgendorf, 1897, p. 205 (— *C. hyalina* Hincks, 1868, p. 184 ?)

Among the specimens received from Professor Benham is a slide labelled "Type *Calycella parkeri* Hilgendorf." The species does not resemble a *Calycella*, but is a *Gonothyraea*, possibly *G. hyalina* Hincks. But the specimen is not in good condition; all the hydrothecae are more or less crumpled and collapsed, especially towards the aperture, so that it is impossible to say with certainty what the form of the margin has been. Hilgendorf says that the thecostome may be either "entire, wavy, or regularly serrated with small even teeth." The hydranths are similar to those of *Obelia*, but seem more slender than we are accustomed to find them in that genus. They are all retracted into the hydrothecae, with the tentacles straight up, surrounding the proboscis: in this state the tentacles just about reach the margin of the hydrotheca, or a little above it, while the proboscis is considerably shorter. This is not in accordance with Hilgendorf's statement that "when in a state of retraction it projects above the retracted tentacles."

The gonangia mostly contain three or four gonophores, or have them borne outside the capsule and attached to the blastostyle in a cluster. The gonophores themselves are too shrunken and too deeply stained to allow their structure to be seen clearly, but the characteristic tentacles can be traced on some of them.

In *G. hyalina* Hincks says that the hydrothecae have "the rim cut out into numerous shallow denticles of castellated form, slightly indented at the top," and in one or two of the hydrothecae of *G. parkeri* I find fragments of the rim which seem to present a similar aspect; I think, therefore, that the two forms are probably identical. The gonosome also appears to agree with that of *G. hyalina.*

Clytia johnstoni (Alder).

Hincks, 1868, p 143: Hartlaub, 1901, p. 364.

Some specimens from French Pass, which Hartlaub examined, are said by him to be undoubtedly a *Clytia*, and are, with somewhat less certainty, referred to this well-known and widely distributed species.

Orthopyxis caliculata (Hincks).

Campanularia caliculata Hincks, 1868, p. 164: Farquhar, 1896, p. 459 (as var. *makrogona*).
Orthopyxis caliculata Bale, 1914*a*, p. 71 (synomymy).

The species which Coughtrey first described as *C. integra* and afterwards as *C. caliculata* is placed by Farquhar under *C. caliculata* var. *makrogona* v. Lendenfeld (*Orthopyxis macrogona* Bale, 1914*a*, p. 77). The reason for this is not apparent: it seems equally probable, or more so, that it may have been a true *O. caliculata;* indeed, Coughtrey's description of the gonangium does not apply very well to either form. Hartlaub thinks the species is probably the same as his *Eucopella crenata* (*Orthopyxis crenata*).

Orthopyxis crenata (Hartlaub). (Fig. 3.)

Campanularia allied to *C. caliculata* Coughtrey, 1876, p. 25, note.
Eucopella crenata Hartlaub, 1901, p. 364: Billard, 1905, p. 332; 1906, p. 71.
Not *Eucopella crenata?* Hartlaub, 1905, p. 568: Billard, 1907*b*, p. 170.
Not *Orthopyxis crenata* Nutting, 1915, p. 67.

Hydrorhiza broad, flattened, forming an irregular network; pedicels very variable in length, more or less undulated, often with one or more constrictions; a single spherule below each hydrotheca.

Hydrothecae large, obconic, wall smooth or with 2-4 strong undulations; in the wider aspect very thick, the thickening mostly extending from base up to just below rim, in the narrow aspect not much thickened except at base; border rising just above top of thickening, very thin, everted horizontally, furnished with shallow teeth, about 15 (or according to Hartlaub 12-14), often difficult to see.

Gonothecae large, strongly compressed, broadly truncate above, thick-walled with undulated surface, with short smooth stalk, enclosing two medusae (Hartlaub).

Loc.—French Pass (Hartlaub): Sumner (Chilton): west coast of Africa; Gambier Islands (Billard).

Hartlaub refers to thick-walled and thin-walled hydrothecae growing on the same hydrorhiza: these are similar hydrothecae seen in different aspects, as is usual in the genus. *O. macrogona* (v. Lendenfeld) is not, as Hartlaub suggests, the same species, as it has a perfectly smooth border, and differs otherwise. Whether Hartlaub is right in referring to *O. crenata* the hydroid which Coughtrey considered allied to *Campanularia integra* is impossible to determine.

The hydrothecae of *O. crenata* vary greatly in form. Some are smooth and with the wall about equally thick from base up to just below margin; others have the outline wavy, and in such cases the undulations of outside and inside surfaces do not always correspond. The thickening of perisarc (as seen in the broad aspect) is more pronounced than in most species, recalling *O. compressa*. This thickening ends abruptly just below rim, which, being very thin and usually turned out horizontally, causes the teeth to be very commonly indistinguishable in the ordinary side view. Hydrothecae larger than those of any other species I have seen.

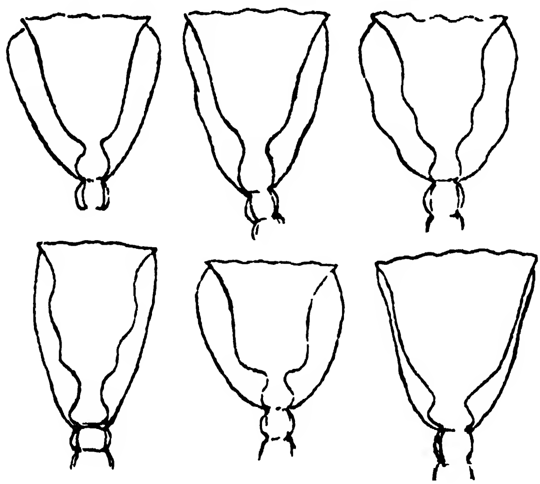


FIG. 3.—*Orthopyxis crenata* (Hartlaub). × 40.

Pedicels may be scarcely longer than hydrothecae, or many times as long; their undulations may be very pronounced or only slightly indicated, and thickness of perisarc varies considerably.

I saw no gonangia, and quote Hartlaub's description.

(The form figured by Nutting is that which Hartlaub referred doubtfully to *E. crenata*, but which he afterwards recognized as distinct, and which Jäderholm calls *Campanularia lennoxensis*.)

Silicularia bilabiata (Coughtrey). (Fig. 4.)

Campanularia bilabiata Coughtrey, 1874, p. 291, 1875, p. 299; 1876, p. 25: Farquhar, 1896, p. 460

Hypanthea bilabiata Hilgendorf, 1897, p. 213: Bale, 1914*a*, p. 89

This species may readily be identified by Coughtrey's figure of the hydrotheca, which is much larger and of longer proportions than that of *S. campanularia*; among them, however, are a few with much shorter hydrothecae, these being mostly such as have very short pedicels. The ordinary pedicels attain the height of about 6 mm. or 7 mm., and are very thick, with much-thickened walls, which are narrowed in at base so that diameter at point of attachment is little more than that of interior of tube; in this respect they resemble those of *S. campanularia*. Hilgendorf specially mentions this character, but his figure represents a very thin-walled pedicel. Both Coughtrey and Hilgendorf note that hydrothecae are set on pedicels at an angle of 45°; this character is not constant, but I find it in most of the hydrothecae, and when it occurs it is always the

lower lip which is bent downward. The condition, however, is equally common in *S. campanularia*.

The gonangia are large and pear-shaped, but apt to be very irregular in outline; the largest which I saw were simply rounded at top; shorter ones were more or less truncate, which is presumably a matter of development. They taper down to a very narrow base, smaller than that of the hydrotheca-stalks, and those which I saw were mostly erect, while those of *S. campanularia* are more often decumbent.

Specimens from Professor Chilton were very perfectly preserved, the perisarc not having suffered the slightest contraction; one of Coughtrey's specimens, from the Dunedin Museum, had been dried, and, as always happens in such circumstances, the thick perisarc of the hydrothecae was much shrivelled and distorted. The hydrothecae were somewhat shorter than in Professor Chilton's specimens, but this may be more or less

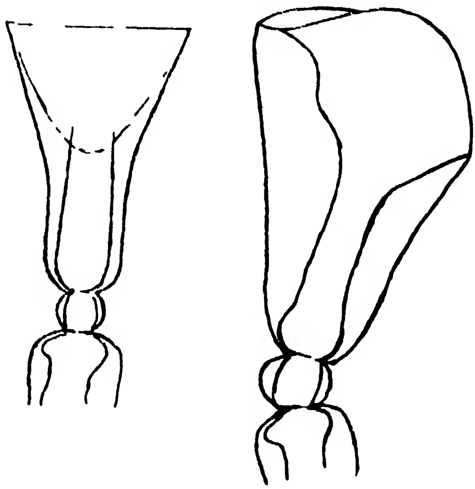


FIG. 4.—*Silicularia bilabiata* (Coughtrey). × 40.

the effect of the general shrinkage. The gonangia were on Coughtrey's specimen, and probably some of the irregularity which characterizes them is due to their having been dried, though they appear to have suffered less than the hydrothecae and their pedicels. The latter seem to have been originally thin-walled, a condition accentuated no doubt by shrinkage due to drying.

Hilgendorf has classed *Eucopella campanularia* as a synomym of *C. bilabiata*, but this is erroneous, and there is scarcely a doubt that his *Hypanthea asymmetrica* is really the same as *E. campanularia*.

Loc.—Timaru (Coughtrey): Tomahawk, Dunedin (Hilgendorf): Sumner (Chilton): Oamaru rocks (Morris).

Silicularia campanularia (v. Lendenfeld).

Eucopella campanularia v. Lendenfeld, 1883, p. 497 (in part): Bale, 1884, p. 60; 1888, p. 751: Mulder and Trebilcock, 1914, p. 9.
Hypanthea asymmetrica Hilgendorf, 1897, p. 212: Hartlaub, 1901, p. 366.
Silicularia campanularia Bale, 1914*a*, p. 84.
? *Eucopella reticulata* Hartlaub, 1905, p. 569.

Hilgendorf's account of *Hypanthea asymmetrica* and *H. bilabiata* is unsatisfactory; so far as features of specific importance are concerned

there is nothing in the account of either species which would not apply to the other, except the description of the pedicels, which are said to be smooth in *H. bilabiata*, but to have occasional sharp constrictions in *H. asymmetrica*. In reality *H. bilabiata* is equally subject to these irregularities, which simply indicate the points at which regeneration has occurred. The distinction between these two species, at least so far as the trophosome is concerned, seems to depend almost entirely on size of hydrothecae and hydranths. The former, in *H. bilabiata*, often attain 1 mm. in length; in *S. campanularia*, which I consider identical with *H. asymmetrica*, I do not find the largest to exceed about 0·67 mm., either in Australian specimens or in Professor Chilton's. The hydrothecae of *S. bilabiata* are, as a rule, longer in proportion to their width than those of the other species, and the gonangia are longer and more erect.

Hartlaub mentions that he found his specimens intermixed with his *Eucopella crenata*, so that at first it appeared that the two forms of hydrothecae belonged to the same hydroid; on further examination, however, he traced them to two different hydrorhizas growing together. No doubt it was a similar association which led von Lendenfeld to describe the hydrothecae of *S. campanularia* and an *Orthopyxis* (perhaps *O. compressa*) as forms of one species. In the present collection *O. crenata* and *S. campanularia* are found, but not in company.

Loc. Kuri Beach (Hilgendorf): French Pass (Hartlaub): Lyttelton Harbour (Chilton)· Port Phillip; Port Jackson; ? Falkland Islands (Hartlaub).

Fam. LAFOEIDAE.

Hebella calcarata (L. Agassiz).

Lafoea scandens Bale, 1888, p. 758.
Hebella scandens Farquhar, 1896, p. 460: Bale, 1913, p. 117.
Hebella calcarata Bale, 1915, p. 251 (synonymy).

Fam. HALECIIDAE.

Halecium delicatulum Coughtrey.

Halecium delicatula Coughtrey, 1875, p. 299; 1876, p. 26: Farquhar, 1896, p. 461.
Halecium delicatulum Ridley, 1881, p. 103: Hartlaub, 1901, p. 368; 1905, p. 613: Stechow, 1913, p. 79.

Recorded by Hartlaub from French Pass, and by Ridley from Punta Arenas. Ridley describes the gonangia.

Halecium parvulum Bale.

H. parvulum and *H. gracile* are now commonly regarded as synonyms of *H. flexile* Allman. (See Bale, 1915, p. 246.)

Fam. CAMPANULINIDAE.

Campanulina humilis n. sp. (Fig. 5.)

Hydrorhiza filiform, delicate, giving rise to numerous slender closely-undulated pedicels, each supporting a single hydrotheca; pedicel expanding gradually to base of hydrotheca.

Hydrothecae slender, upper one-third with several folds or irregular converging segments; a distinct diaphragm at base.

Gonosome ?

Loc.—" Hull of 'Terra Nova'" (D. G. Lillie).

In this delicate species pedicels average about 0·27–0·30 mm. in length, and hydrothecae range from about 0·20 mm. to 0·30 mm. There is much variation in undulation of pedicels, some being smoother than others; generally undulations are fainter in distal portions. Abrupt divisions may

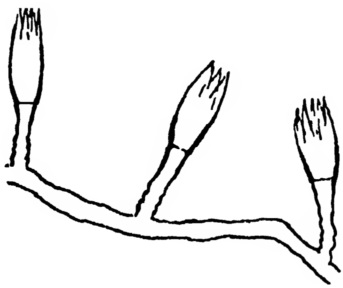


FIG. 5.—*Campanulina humilis* n. sp. × 40.

be seen occasionally, indicating where regenerations have occurred. No constriction between hydrothecae and pedicels, which slightly enlarge and join hydrothecae without interruption, so it would be impossible to say where hydrothecae begin if it were not for diaphragm. The latter is extremely thin, and the perisarc throughout is of the thinnest.

In the only specimen all the hydranths were retracted, so I could not ascertain whether the tentacles were webbed, as is usual in the genus.

Thyroscyphus simplex (Lamouroux).

Laomedea simplex Lamouroux, 1816, p. 206.
Campanularia tridentata Bale, 1893, p. 98.
Sertularella tridentata Hartlaub, 1900, p. 46.
Thyroscyphus tridentatus Hartlaub, 1901, p. 369.
Parascyphus simplex Ritchie, 1911, p. 160.
Thyroscyphus simplex Bale, 1915, p. 245 (synonymy).

Recorded by Hartlaub from French Pass, and by Ritchie from the British coast and the South Atlantic.

Fam. SERTULARIIDAE.

Of the genera here included in the Sertulariidae, *Thuiaria* and *Sertularella* are taken according to Levinsen's definitions. I do not, however, adopt his genus *Odontotheca*, as its characters appear to me insufficient to warrant its separation from *Sertularia*. Levinsen himself, though classing *S. minima* as an *Odontotheca* (1913, p. 308), states on p. 264 of the same work that it is a true *Sertularia*. All the other *Sertulariae* mentioned in the present paper would come under the *Odontotheca* of Levinsen.

The species with six or more teeth on thecostome, and, so far as is known, without operculum, are referred to the genus *Stereotheca*, under Synthecidae.

Thuiaria buski (Allman).

Desmoscyphus buskii Allman, 1876, p. 265: Farquhar, 1896, p. 465.

The untenable genus *Desmoscyphus* embraced Sertularians in which the opposite hydrothecae are in contact with each other in front, and it included forms some of which belong to the genus *Sertularia*, and others to *Thuiaria*, as now understood. *D. buski*, as Captain Totton informs me, is extremely closely allied to the *Thuiaria bicalycula* of Coughtrey, and it is undoubtedly to be referred to the same genus.

Selaginopsis monilifera (Hutton).

Sertularia monilifera Hutton, 1872, p. 257: Coughtrey, 1874, p. 282; 1875, p. 301; 1876, p. 30.
Thuiaria cerastium Allman, 1876, p. 271.
Thuiaria monilifera Thompson, 1879, p. 111: Farquhar, 1896, p. 465.
Dictyocladium dichotomum Allman, 1888, p. 77: Levinsen, 1913, p. 277.
Selaginopsis dichotoma Billard, 1910, p. 16: Bale, 1915, p. 266.

I have a fragment of *S. monilifera* from the collection of Hutton's types in Dunedin Museum, and specimens of Allman's types of *T. cerastium* and *D. dichotomum* from British Museum. The *Dictyocladium* is more robust, with hydrothecae more distant; otherwise it does not differ essentially from the other specimens. Hydrothecae very variable in the extent to which distal portion is prolonged. It is singular that Allman, when describing *Dictyocladium*, should have overlooked his earlier account of *T. cerastium*. As I have elsewhere remarked, the "Challenger" figure is very inexact- that of *T. cerastium* is more like the specimens; and this is notably the case with the gonangia, which are figured correctly as springing from one of the branches just above the axil, instead of from the axil itself as in the "Challenger" figure.

I have to thank Captain Totton for pointing out to me the identity of these forms.

Sertularella edentula n. sp. (Fig. 6.)

Hydrocaulus branched, fascicled in older portions, each internode of rachis bearing a single hydrotheca on one side, and a pinna between two hydrothecae on the other; pinnae alternate, not close, long, straight, narrow at origin, with nodes few or absent.

Hydrothecae alternate, the two series sometimes more widely separated behind than in front, very stout, tubular, slightly narrowed upward, adnate in their whole length, somewhat contracted at aperture, which is at an angle of about 45° with axis of pinna, border circular, quite smooth, operculum of three valves.

Gonangia springing from rachis, very large and stout, in back or front view obovate, in side view with back more convex than front, a wide shallow longitudinal depression running whole length of dorsum and over summit; aperture on ventral side, nearly reaching top, circular, margin not thickened.

Loc.—Cape Maria van Diemen, ten miles north-west, 50 fathoms (Chilton).

This is one of that group of species which, from the immersed hydrothecae, as well as from their biserial and unpaired arrangement, were formerly regarded as typical *Thuiariae*. It somewhat resembles *S. lata*, but is a more robust species, with the hydrothecae larger and more fully divided off from the hydrocaulus. The pinnae, which may reach over 1 in. in length, may be wholly unjointed, or there may be

a node near the end. The hydrothecae are less close in the distal than in the proximal portions of the pinnae, and where a node occurs the highest hydrotheca on the lower internode has its border nearly horizontal.

The form of the hydrotheca-margin is characteristic, having no trace of the three or four emarginations usual in the genus, but being perfectly round and smooth, and in general showing no indication of the operculum. In this group the operculum is readily detached, yet in such species as *S. lata*, for example, one generally finds its remains attached to the hydrotheca-margin (though it is only in well-preserved specimens that the four valves are distinct), but in the species before us the operculum generally comes clean away, leaving no trace. Only

FIG. 6.—*a*, *Sertularella edentula* n. sp.; × 25. *b*, *Sertularella edentula*: gonangium; × about 10.

here and there can a remnant be found, and then usually insufficient to indicate its original form; however, after careful search I succeeded in finding a few specimens intact, all of which were trivalvate, though the margin showed no corresponding divisions.

In many of the hydrothecae is found a membranous diaphragm (or its remains) situated at a small but variable distance within the margin and continuous with a membrane lining the hydrotheca; it is pierced by a circular central orifice of very variable size (in some cases, however, I could not find this opening). It is evidently a temporary structure, as even where the orifice is distinct it is frequently so small that the hydranth could not possibly pass through it. Hartlaub (1900, p. 11) mentions finding a similar structure, which he calls the "velum," in an American species.

The gonangia are very large (about 4·3 mm. in length and 1·8 mm. in diameter), and their form is very distinctive. Looking at them from the back or the front the longitudinal depression is not noticeable, except perhaps on the top, but seen sidewise it gives the impression of two longitudinal ridges. The aperture, before opening, can only be distinguished by an extremely fine suture.

The only specimen was about 8 in. high, with two lateral branches near the base, where the stem was about 2 mm. in thickness.

Sertularella johnstoni (Gray).

Sertularia johnstoni Gray, 1843, p. 294: Hutton, 1872, p. 256: Coughtrey, 1874, p. 281: Hilgendorf, 1897, p. 207.
Sertularia subpinnata Hutton, 1872, p. 256.
Sertularia delicatula Hutton, 1872, p. 256.
Sertularella johnstoni Coughtrey, 1875, p. 299; 1876, p. 26: Allman, 1876, p. 261: Thompson, 1879, p. 101: Bale, 1886, p. 21: Farquhar, 1896, p. 463: Hartlaub, 1900, pp. 22, 30, &c.; 1905, p. 628: Billard, 1910, p. 13 (in part): Bale, 1914*b*, p. 25: Jäderholm, 1916 17, p. 10.
Sertularella capillaris Allman, 1885, p. 133.
Sertularella purpurea Kirchenpauer, 1884, p. 49: Bale, 1886, p. 36.
Symplectoscyphus australis Marktanner-Turneretscher, 1890, p. 226.
Not *S. johnstoni* Bale, 1884, p. 109; 1893, p. 102; which I have later referred to *S. divaricata*.

Hartlaub (1900) considered *S. capillaris*, *S. purpurea*, *S. australis*, along with *S. pygmaea* Bale, as synonyms of *S. johnstoni*. I had in 1886 referred *S. purpurea* to that species, but I think that *S. pygmaea* is nearer to *S. divaricata*. Billard agrees with Hartlaub, after examining Allman's specimens of *S. johnstoni* and *S. capillaris*, the latter of which he says has three teeth on the hydrotheca, not four as Allman states. Billard also considered *S. divaricata* as synonymous, but I have given reasons for dissenting from this view (1914*a*), with which opinion Jäderholm concurs (1916-17).

Type specimens of Hutton's *S. subpinnata* were received from the Dunedin Museum, and Professor Chilton sends typical specimens of *S. johnstoni* from Island Bay.

Sertularella columnaria Briggs.

Briggs, 1914, p. 293.

Hitherto this species is only recorded from near Cape Pillar, Tasmania. A single fragment occurs in Professor Chilton's collection, but the part of New Zealand from which it came is uncertain.

The species seems to bear the same relationship to the *johnstoni* group that *S. gigantea* does to the *rugosa* group; its gonosome, however, is unknown.

Sertularella pygmaea Bale.

Bale, 1881, p. 25; 1884, p. 108; 1914*b*, p. 25: Farquhar, 1896, p. 464: Hartlaub, 1900, pp. 30–32 (under *S. johnstoni*).

Considered by Hartlaub to be a form of *S. johnstoni*. (*Vide* Bale, 1914*b*.)

Sertularella simplex (Hutton). (Fig. 7.)

Sertularia simplex Hutton, 1872, p. 257: Coughtrey, 1874, p. 283 (in part).
Sertularella simplex Coughtrey, 1875, p. 300 (in part): 1876, p. 27.
Sertularella fusiformis Hincks var. *nana* Hartlaub, 1901, p. 372.

Hydrocaulus simple (or rarely branched Hutton), twisted at base, about 8 mm. in height, divided by narrow twisted joints into internodes, each bearing a hydrotheca on upper part.

Hydrothecae adnate a little less than half their height, divergent and directed somewhat forward, smooth, narrowed upwards and contracted near aperture, margin slightly everted, with four teeth; three internal compressed vertical teeth, two of which are within the two upper emarginations of border, and the third below inferior marginal tooth.

Gonangia about 3½–4 times length of hydrothecae, borne on lower portion of hydrocaulus, ovate, with a few distinct coarse rugae on upper part, and tubular neck; summit with about four conical teeth.

Loc.—Lyall Bay (Hutton): Sumner (Hartlaub).

I have formerly ranked *S. simplex* as a synonym of *S. polyzonias*, as also has Farquhar, but examination of one of Hutton's specimens from the Dunedin Museum shows this to be erroneous. They agree with Coughtrey's figure of the type (1874, fig. 8); the internal teeth, however, are not shown. Fig. 10 is no doubt a different species, and probably fig. 9 also, though Hartlaub includes it with the type.

The species is analogous to the Australian *S. indivisa*, but the hydrothecae are smooth and have four emarginations of the border instead of three; they are also larger, and have the lip rather more everted. The gonangia are of the same type, but larger, with neck more pronounced and the circular rugae fewer and less sharp.

Hartlaub's reference of this form to *S. fusiformis* Hincks seems to me doubtful.

Sertularella robusta Coughtrey.

Sertularia simplex Coughtrey (in part), 1874, p. 283.
Sertularella simplex Coughtrey (in part), 1875, p. 300; 1876, p. 27.
Sertularella robusta Coughtrey, 1875, p. 300; 1876, p. 27: Farquhar, 1896, p. 464.
? *Sertularella* sp. Thompson, 1879, p. 101.
Sertularella tenella Hartlaub, 1901, p. 370.

This form, originally described by Coughtrey as one of the varieties of *S. simplex* Hutton, was figured by him in 1874 (pl. xx, fig. 10), but afterwards described as a distinct species. Hartlaub refers it, along with several other species, to the *S. tenella* of Alder (Hincks, 1868, p. 242). He only cites Coughtrey's original description, and seems to have overlooked the later references (1875 and 1876), in which Coughtrey named the form *S. robusta.*

I cannot agree with Hartlaub's reference of the present species, with *S. microgona* von Lendenfeld and *S. angulosa* Bale, to *S. tenella*, as these forms all possess three distinct internal teeth in the hydrothecae, which in *S. tenella* are wanting.

Hartlaub's specimens were from French Pass.

Sertularella crassiuscula n. sp. (Fig. 8.)

Sertularella solidula Hartlaub, 1900, p. 71; 1901, p. 371.
Not *S. solidula* Bale, 1881, p. 24; 1884, p. 106.

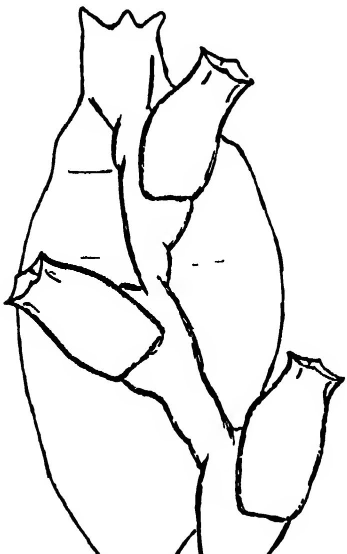
Hydrocaulus simple, twisted at base, about 10–12 mm. in height, divided by twisted joints into internodes, each bearing a hydrotheca on upper part.

Hydrothecae adnate about half their height, divergent, very stout, mostly thick-walled, smooth, usually with extreme distal part bent outward; border with four marginal teeth or shallow emarginations; three internal compressed vertical teeth, two of which are within the two upper emarginations of border, and the third below inferior marginal tooth.

Gonangia large, about 3 3½ times the length of hydrothecae, obovate, with a few transverse rugae and no distinct neck, flattened at top, without distinct teeth.

Loc. French Pass (Hartlaub): Akaroa (Chilton): "New Zealand" (Hincks collection, British Museum).

Notwithstanding that this species has the mouth of the hydrotheca distinctly four-sided, Hartlaub has referred it to *S. solidula*, which has the aperture three-sided, on the ground that several species of *Sertularella* vary in this respect. I have not met with such; in any case, among the



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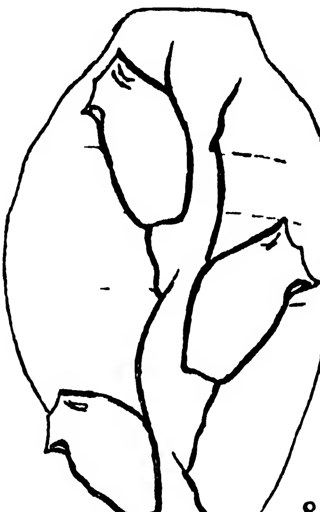

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FIG. 7.—*Sertularella simplex* (Hutton). × 40.
FIG. 8.—*Sertularella crassiuscula* n. sp. × 40.

many forms of *S. indivisa* (of which species *S. solidula* is a variety) I have never seen a four-sided specimen, and, on the other hand, in the *polyzonias* group the four-sided condition seems invariable. It is even proposed by Stechow, in a recent paper, to establish distinct genera for the three-sided and the four-sided species.

Undoubtedly, however, a strong similarity exists between the present species and the form described as *S. solidula* by me, a similarity which depends mainly on the very stout hydrothecae, the thick solid-looking perisarc, and the relative shortness of the internodes, which are swollen, and abbreviated below. In all these points the species differs from *S. simplex*.

The hydrothecae are larger than those of *S. solidula*, and have always four emarginations of the border, which are very shallow, especially in

those near summit of shoot, where border often appears almost flat and very thin. The hydrotheca is commonly somewhat constricted on outer side, just below border, and the internal teeth are strongly developed.

Gonangia considerably larger than those of *S. solidula*, but otherwise much resemble them. They differ from those of *S. simplex* in absence of conical teeth on summit.

Specimens from the Hincks collection in the British Museum have somewhat shorter hydrothecae than those received from Professor Chilton.

Sertularella polyzonias (Lin.).

Farquhar, 1896, p. 463.

S. polyzonias was included in Farquhar's list in the belief that it was the same as *S. simplex* (Hutton), which is not the case. I do not think that the true *S. polyzonias* has been recorded either from New Zealand or from Australia, the form from Bass Strait which I formerly assigned to that species being more nearly allied to *S. mediterranea* Hartlaub.

Sertularella integra Allman.

Sertularella integra Allman, 1876, p. 262: Farquhar, 1896, p. 464: Hartlaub, 1900, p. 65.

I have received a fragment of the type specimen from British Museum. The species is readily identifiable by Allman's figure the rugose condition of the upper sides of the hydrothecae is even more pronounced than in the figure; the outline at this part is quite deeply crenate.

The mouth portions of the hydrothecae are much broken, but I am convinced that Allman's statement, "The perfectly even rim of the hydrotheca, destitute of all trace of teeth, is an obvious feature," is incorrect. There seem to have been three or four (probably four) shallow emarginations of the border, as usual in the genus. The internal "conical process" referred to by Allman is one of the internal teeth now known to exist in so many species. All three are present, one being on the apocauline side, the other two, as usual, equidistant from it and from each other. They are here very large, but being thin and hyaline they are inconspicuous, especially in Canada balsam.

Sertularella subarticulata (Coughtrey).

Thuiaria subarticulata Farquhar, 1896, p. 465: Hilgendorf, 1897, p. 210.
Sertularella subarticulata Briggs, 1918, p. 36.

Type specimens were received from the Dunedin Museum. Former accounts, which described the hydrothecae as having two or four teeth, are erroneous; the species is undoubtedly tridentate, but the superior tooth, seen laterally, often appears split. The hydrothecae are extremely brittle.

Sertularella quadridens (Bale).

Thuiaria quadridens Bale, 1884, p. 119; 1914*b*, p. 12: v. Lendenfeld, 1884, p. 915: Weltner, 1900, pp. 585 86: Farquhar, 1896, p. 465.
Sertularella quadridens Ritchie, 1910c, p. 818: Billard, 1910, p. 11: Levinsen, 1913, p. 279: Jädenholm, 1916, p. 6.
Thuiaria vincta Allman, 1888, p. 68.

Billard states (1910) that observation of the type of *T. vincta* Allman shows its complete identity with *S. quadridens*.

Thuiaria bicalycula (Coughtrey). (Fig. 9.)

Hydrallmania (?) *bicalycula* Coughtrey, 1875, p. 301; 1876, p. 29.
Hydrallmania bicalycula Farquhar, 1896, p. 465

Hydrocaulus monosiphonic, rarely branched, pinnate. Stem thick, fistulous, divided into internodes of variable length, each bearing from 1 to 6 pairs of hydrothecae. Pinnae rather irregular, alternate to sub-alternate, rarely opposite, stout, divergent nearly at right angles, borne on rather short thick apophyses; proximal internodes very long, bearing up to 16–18 pairs of hydrothecae, one or two distal internodes with few pairs sometimes present; pinnae in some cases without nodes.

Hydrothecae in pairs, opposite, adnate in front, most of their length vertical, upper portion turned outward and narrowed; aperture vertical, widened laterally, with two lateral lobes, facing outward and forward; a large smooth wide tooth inside lower margin.

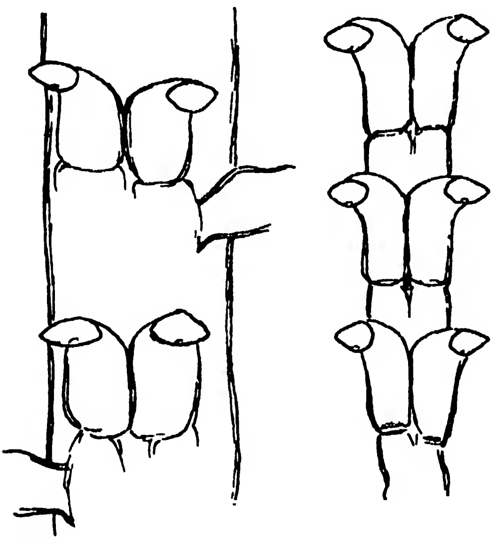

FIG. 9.—*Thuiaria bicalycula* (Coughtrey): stem and pinna. × 40.

Gonothecae abundant on the pinnae, large, length 0·13 in., width 0·8 in., urceolate, mouth small, round, entire, on a short simple neck; on the widest part of the capsule, about one-fourth of its length from mouth, is a faint rim; capsule subpedicellate. (Coughtrey.)

There is little doubt that this is the same as Coughtrey's species, though the original specimen seems to have been more robust. Coughtrey says that the stem, close to its origin, gives off from 8 to 20 shoots, which, within an inch, bifurcate into long flexuous branchlets 7 in. long. In our specimen several shoots rise from a common point of the hydrorhiza, and are unbranched; in one instance only I observed a secondary branch. The pinnae are mostly alternate, and in parts they are regularly arranged, one being given off below every pair of hydrothecae on the rachis; but, while this arrangement preponderates to such an extent as to be fairly considered typical, irregularities are frequent, and in a few cases the pinnae are opposite.

The species is nearly allied to *T. tuba* (Bale), but the stems and pinnae are very much stouter, hydrothecae are much larger and generally face

more forward, and the internal tooth is characteristic. The stems and pinnae are so thick that the tips of hydrothecae often project only slightly, or not at all, beyond them, and they are mostly not constricted between the pairs of hydrothecae. The pinnae do not generally run out into tendrils and anastomose, as in *T. tuba*, but I have seen instances.

Still closer to the present species is *T. buski*, which was the type of Allman's proposed genus *Desmoscyphus*. In this group the *Desmoscyphus* character is found in its most pronounced form, hydrothecae being seated more on the front of hydrocaulus than on its sides. As noted by Allman in regard to *D. buski*, the greatest diameter of the hydrothecae is in view when they are seen in a position midway between the front and the side aspects. The main difference between these two species is that in *T. buski* the pairs of hydrothecae on the pinnae are almost in contact with those above and below them, while in *T. bicalycula* they are widely separated.

I have not seen the gonangia; if Coughtrey's figure is correct they are more pyriform than those of the allied forms, in all of which the widest part is near the middle.

I noticed in one shoot an interesting abnormality in the arrangement of the hydrothecae on the stem: a gradual transition occurred from the opposite to a perfectly regular alternate condition, which after a short space returned gradually to the normal arrangement. Where the alternate order prevailed the hydrocaulus was somewhat narrower than elsewhere.

The species does not seem to have been observed hitherto since Coughtrey described it.

Loc.—Wickliff Bay, Bluff Harbour (Coughtrey): Cape Maria van Diemen, ten miles north, 50 fathoms (Chilton).

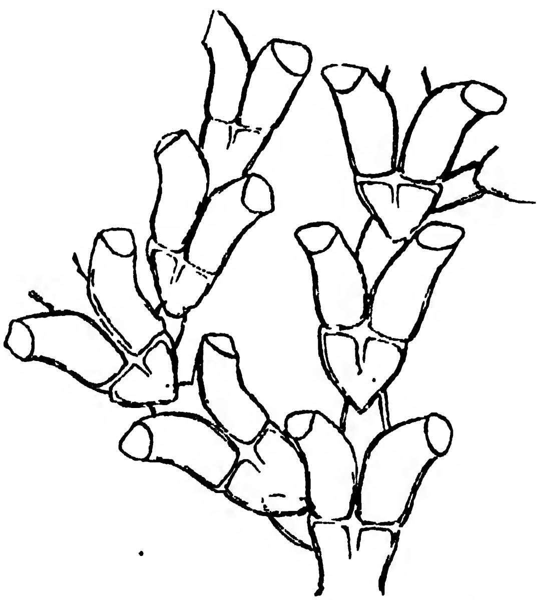

Fig. 10.—*Thuiaria farquhari* n. sp. × 40.

Thuiaria farquhari n. sp. (Fig. 10.)

Hydrocaulus short, monosiphonic, pinnate, divided into short internodes, bearing 1–3 (mostly 2) pairs of hydrothecae. Pinnae quite irregular, on

extremely short apophyses, internodes bearing usually 1 2 pairs of hydrothecae, and occasionally a secondary ramule.

Hydrothecae in pairs, opposite, adnate in front, upper half curving outward and forward and becoming narrower; aperture vertical, facing outward and forward, with two large angular lateral lobes, thinned away to margin.

Gonangia ovate, widest near the middle, with faint annular undulations, most distinct in upper half; aperture circular, margin not thickened, a circlet of thick perisarcal processes projecting into the neck.

Loc. Lyttelton (Chilton).

The largest specimen is about ¾ in. long; it has one pinna on right side, then two on left, then five on right, so that no definite order can be traced. Stem and branches do not appreciably differ, either in size or form, and hydrothecae have the same arrangement throughout. In striking contrast to the last species, hydrocaulus is much constricted between pairs of hydrothecae, and especially between internodes, where joints are of oblique type, sloping backward and upward, so that internode, which is very wide at base of hydrothecae, narrows rapidly downward to a point in front, while part above hydrothecae is narrower throughout. Between the pairs on an internode, though the joint is wanting, the constriction is still marked. Upper part of hydrothecae is turned so much forward that in front view anterior lateral tooth is scarcely noticeable, being so much foreshortened.

The gonangia are similar to those of the allied species, *T. tuba* and *T. buski.*

Sertularia episcopus (Allman).

Sertularia fusiformis Hutton, 1872, p. 257: Coughtrey, 1874, p. 285: Ridley, 1881, p. 105 ?: Pfeffer, 1892, p. 568.

Sertularia longicosta Coughtrey, 1875, p. 300; 1876, p. 28.

Sertularella episcopus Allman, 1876, p. 263: Farquhar, 1896, p. 464: Hartlaub, 1905, p. 658.

This species, having the character formerly considered typical of *Sertularella,* and the name *fusiformis* having been preoccupied in that genus, Allman named it *S. episcopus* and Coughtrey *S. longicosta.* The species described in Allman's paper of 1876 were mentioned in a preliminary note in *Nature* in 1874, with short descriptions to ensure priority; hence the adoption of the name *S. episcopus* in preference to to *S. longicosta.*

It is not easy to ascertain the true form of the gonangia, as they vary so much, and have the appearance of having shrunk considerably in drying. Those which appear the best preserved are of an elongated somewhat fusiform shape, with a deep narrow dorsal channel running from end to end, formed by an inflection of the perisarc: this channel being narrow and abrupt, its edges form two longitudinal ridges, which are approximated, or sometimes quite close together, perhaps by shrinkage. At the summit are generally two blunt angles, terminating these ridges, and the aperture, which is subterminal, is just in front; it has no definite border, and looks as if simply broken through.

The hydrotheca-apertures are, in the form of their two lateral lobes, similar to those of *S macrocarpa* Bale (*Odontotheca macrocarpa* Levinsen). *S. mccallumi* (M. & T.) has the same type of aperture, and also agrees with the present species in the very unusual character of having each hydrotheca on a separate internode. No opercula could be distinguished

on the dried specimen, which was one of Hutton's types, from the Dunedin Museum. The lateral lobes are very large and deep, and have the border thickened.

Ridley (1881) mentions some specimens from south-west Chile under the name of "*Sertularia fusiformis* Hutton ? (*non* Hincks)," and says, "This is certainly not the species assigned to Hutton's species by Allman under the name of *S. episcopus*." Hartlaub (1905) says that he has no doubt of the identity of *S. fusiformis* with *S. episcopus*, neither does he doubt that Ridley had the same species before him. Ridley says, "The growth is very strong, and the calicles large (·425 mm. in diameter at their middle), but they should be described as quadridentate, though the interior and exterior teeth are very short. The crest, described by Coughtrey on the upper side of the gonangium, is here, at any rate, a tube which opens in the side of the gonangium." In Hutton's specimens I find no trace of the two small teeth referred to by Ridley. The middle diameter of the hydrothecae ranges from about 0·33 mm. to 0·4 mm.

Pfeffer records the species from the Straits of Magellan.

Sertularia operculata Lin.

Sertularia operculata Farquhar, 1896, p. 462: Bale, 1915, p. 274 (synonymy).
Odontotheca operculata Levinsen, 1913, pp. 309, 317.

Of the numerous synonyms mentioned by me in the above-cited paper, *Dynamena fasciculata* Kirchenpauer and *Sertularia crinis* Allman are now associated, along with *S. ramulosa* Coughtrey, as a separate species, under Kirchenpauer's specific name. *Dynamena pulchella* D'Orbigny may be the same form.

Sertularia fasciculata (Kirchenpauer).

Dynamena fasciculata Kirchenpauer, 1864, p. 12.
Sertularia ramulosa Coughtrey, 1874, p. 283; 1875, p. 300; 1876, p. 28: Farquhar, 1896, p. 462.
Sertularia operculata (?) Thompson, 1879, p. 106 (in part).
Sertularia crinis Allman, 1885, p. 139: Farquhar, 1896, p. 462: Bale, 1915, p. 276.
? *Dynamena pulchella* D'Orbigny, 1839–46, p. 26: Hartlaub, 1905, p. 667: Nutting, 1904, p. 55 (in part).

Among Coughtrey's types from the Dunedin Museum is a specimen of his *S. ramulosa*, which I find to be identical with *S. crinis* Allman, and I have now no doubt that Kirchenpauer's *D. fasciculata* is also the same. Hitherto the latter has usually been ranked as a synonym of *S. operculata*, to which species Billard has also referred *S. crinis*.

The difference between *S. operculata* and the present form (whether it be admitted as specific or not) is very obvious. In *S. operculata* all the ramules resulting from the innumerable dichotomous divisions are alike, so that there is no distinction of stem and branches. In *S. fasciculata* the main stem and its principal branches, extending right to the distal extremities of the polypidom, are very conspicuous, differing from the smaller branches in their greater thickness, far longer internodes, and much more distant hydrothecae. These internodes commonly reach about 3 mm. in length, often more, but support only a single pair of hydrothecae, which are close to top. Many of them also give off lateral branchlets, which divide dichotomously into somewhat flabelliform fascicles. The first two or three internodes are long (though still much shorter than

those of stem), and where bifurcations occur in fascicles one of the divisions has its first pair of hydrothecae opposite as usual, while in the other they are generally subalternate.

Hydrothecae much like those of *S. operculata*, but teeth generally more nearly equal; in many cases quite equal, as figured by Allman; while Coughtrey describes one as much larger than the other- a description not borne out by his specimens. No doubt considerable variation occurs.

The mode of branching is, as in allied species, strictly dichotomous, though, where the fascicles branch off, one division (that which continues the rachis) is much thicker than the other. There is, as usual, a hydrotheca at each side of every axil.

Stem-internodes much stouter than hydrothecae situated upon them, and the latter often inconspicuous; it is probably partly on this account, and partly from their being frequently broken off from older portions, that Kirchenpauer has described stem as being without cells.

The gonangia, which are not present in specimens before me, are described as similar to those of *S. operculata*, not to those of *S. bispinosa*.

Thompson, under the name "*S. operculata* (?)" includes *D. fasciculata* K. and *D. bispinosa* Gray, and, though not having seen specimens exactly corresponding to *S. trispinosa* Coughtrey, has "little doubt that it is in reality a mere variety of the present species." He says, "*Sertularia operculata* (?) is of very common occurrence in New Zealand and Australia. There are two very distinct varieties, as indeed is, I think, the case with our British specimens. The first is brown in colour, and forms dense short tufts, 2 or 3 inches in height. The second variety is of a yellowish hue, and occurs in long, trailing, dichotomously-branching shoots, often 2 (according to Kircheupauer 3 or 4) feet in height. This is not merely a difference in age." Coughtrey says of *S. ramulosa* that there are two varieties, coarse and delicate.

Kirchenpauer says that the thread-like stems are densely crowded on a Laminaria, forming clusters 3 ft. or 4 ft. long, and that the individual stems reach 2 ft. in length. His specimens were from Sydney and New Zealand.

Thompson's statement that the species is of very common occurrence in Australia and New Zealand can, I think, only be accounted for by his having mixed up several species. I have specimens of *S. operculata*, *S. bispinosa*, and *S. trispinosa* from both countries, but I have never seen a specimen of *S. fasciculata* other than that from the Dunedin Museum.

Thompson remarks that *S. furcata* Trask is indistinguishable from the present species, so far as the form of gonangia and hydrothecae is concerned. On the Pacific coast of United States *S. furcata* is still regarded by some observers as identical with *D. pulchella* D'Orbigny, a species allied to *S. operculata* and the species before us, and very possibly identical with one of them. I have referred to this subject in another place (1915, p. 276) but I may here summarize the distinctions between the two forms. *S. furcata* is a dwarf form, under 1 in. in height, usually unbranched, and with one or two gonangia borne at base of shoot; it is of the *Desmoscyphus* type—that is to say, hydrothecae forming a pair are in contact or closely approximate in front of hydrocaulus, at least in upper portion. *D. pulchella* is a large species, 9 in. in height, abundantly branched, with numerous gonangia scattered over branches, and is not of the *Desmoscyphus* type, hydrothecae being wide apart, and quite similar to those of *S. operculata*.

Sertularia bispinosa (Gray).

Sertularia bispinosa Farquhar, 1896, p. 462: Hilgendorf, 1897, p. 206: Jäderholm, 1903, p. 281: Hartlaub, 1901, p. 373: Nutting, 1904, p. 56: Bartlett, 1907, p. 61: Billard, 1910, p. 18: Mulder and Trebilcock, 1914, p. 6: Briggs, 1918, p. 37: Jäderholm, 1916 17, p. 15.
Sertularia operculata Hartlaub, 1905, p. 664 (in part).
Odontotheca bispinosa Levinsen, 1913, p. 308.

A specimen from Sumner is in Professor Chilton's collection. Hydrothecae of this species differ from those of *S. operculata* in having upper portion free and abruptly contracted on inner side; gonangia are compressed, with a shoulder at each side often produced upwards into an erect process.

Sertularia unilateralis Allman.

Sertularia unilateralis Allman, 1885, p. 139: Farquhar, 1896, p. 463.
Sertularia bispinosa Billard, 1910, p. 18 (in part).

From the British Museum I have received a portion of one of Allman's specimens. The primary shoots give origin by repeated bifurcations to a number of secondary shoots, all on the same side, which are again subdivided, the primary shoot thus assuming to some extent the character of a stem; its structure, however, only differing from that of the smaller branches by the somewhat more robust internodes and hydrothecae. On the small branches also the two members of a bifurcation are sometimes slightly unequal. The average length of the internodes and hydrothecae is decidedly less than in the ordinary forms of *S. bispinosa*, of which species it may rank as a variety

Sertularia trispinosa Coughtrey.

Sertularia trispinosa Coughtrey, 1874, p. 284: 1875, p. 300: 1876, p. 28: Ridley, 1881, p. 104: Bale, 1884, p. 69, 1886, p. 92: Farquhar, 1896, p. 462: Hilgendorf, 1897, p. 207: Hartlaub, 1905, p. 668: Bartlett, 1907, p. 62: Jäderholm, 1916–17, p. 16.
Odontotheca trispinosa Levinsen, 1913, pp. 309, 318.

Specimens from Coughtrey's material in Dunedin Museum are somewhat more lax and delicate than others I have seen. Though a member of the *operculata* group, the species is sharply distinguished from all the rest by third tooth on hydrotheca-margin. Levinsen's figure of hydrotheca is the best. Hilgendorf erroneously describes gonangia (which he calls "gonophores") as having *two* large teeth on each side of orifice.

Sertularia unguiculata Busk.

Sertularia unguiculata Farquhar, 1896, p. 463: Bale, 1914*b*, pp. 16, 11; 1915, p. 273.

I have given the full synonymy in 1914*b*, p. 16. *Thuiaria ambigua* Thompson is the large form of the species; *Sertularia australis* (Kirchenpauer), described by Thomson in the same paper, is the dwarf form. A specimen of the latter, from Lyttelton, is in Professor Chilton's collection.

Sertularia minima Thompson.

Sertularia minima Farquhar, 1896, p. 462: Hilgendorf, 1897, p. 209: Jäderholm, 1905, p. 24: Thornely, 1908, p. 83: Billard, 1909*a*, p. 194: 1910, p. 17: Jäderholm, 1910, p. 3: Hilgendorf, 1911, p. 541: Ritchie, 1911, p. 845: Mulder and Trebilcock, 1914, p. 39: Bale, 1915, p. 269 (synonymy): Briggs, 1918, p. 37.
Odontotheca minima Levinsen, 1913, p. 308.

From Dunedin Museum I have one of Coughtrey's specimens of this most variable species. It differs somewhat from his figures, having more compact internodes, with hydrothecae less divergent at base and more so above. Specimens from Port Phillip agree more perfectly with the figures. These forms have rarely more than 10 or 11 pairs of hydrothecae, and do not exceed about 3 mm. in height. The hydrorhiza forms a network running over fronds of algae; it is flat and ribbon-like, and at short intervals along each side are little perisarcal loops running inward from margin; these are wanting in some of the varieties. The nodes are oblique, but this feature is sometimes scarcely noticeable, especially in lower part of the colony. The shoots are borne on slender peduncles, mostly consisting of an apophysis and a very short fusiform internode. The nodes at this part are very oblique, and are sometimes referred to inaccurately as "twisted joints."

The variations depend on the respective sizes of the colonies and of their several parts, degree of distinctness and obliquity of nodes, compactness or otherwise of internodes, degree of divergence of hydrothecae, and especially the character of hydrorhiza. The largest variety which I have seen is the form which I originally described as *S. pumiloides*, from Port Phillip, reaching about 6 mm. in height, and consisting of about 12–16 internodes. Its hydrothecae are larger than those of typical forms, and its gonangia exceed in size those of any other variety, being about 1·5 mm. by 1·0 mm., while the joints are more markedly oblique. The hydrorhiza is reticulated, delicate, and in parts scalloped alternately on sides, so as to present a zigzag appearance; marginal loops of perisarc are not present. Another specimen from the same locality has nodes transverse, with hydrothecae more divergent; its hydrorhiza is stout, filiform, dark in colour and not reticulated, being the most conspicuous part of the colony; and it has no trace of marginal loops. The peduncles of shoots in this form are more robust, and have two, sometimes three, fusiform internodes following apophysis. A very similar form from Akaroa is from the Busk collection in British Museum, and another, with up to 20 internodes, is from "New Zealand." On one or two of these varieties I noticed instances where a joint was quite wanting, so that an internode of 4 hydrothecae was formed.

Mulder and Trebilcock also mention having observed several varietal forms, some with the characteristic markings of the hydrorhiza, and others without them. These observers have called attention to the existence in this species and its allies of minute apertures near the bases of some of the internodes, often surrounded by delicate tubular processes.

Hilgendorf has noticed that the shoots spring from points of the hydrorhiza at which branching occurs; this character is not, however, constant, as he supposed.

Idia pristis Lamouroux.

Idia pristis Farquhar, 1896, p. 467: Campenhausen, 1897, p. 311: Jäderholm, 1903, p. 288: Billard, 1907*a*, p. 351; 1910, p. 16: Ritchie, 1910*a*, p. 820; 1910*b*, p. 11: Stechow, 1913, p. 141: Levinsen, 1913, p. 315.
Idiella pristis Stechow, 1919*a*, p. 106; 1919*b*, p. 19.

Jäderholm and Campenhausen considered the form described by Allman was a distinct species; Billard, after examining Allman's types, does not concur.

Fam. SYNTHECIDAE.

Synthecium orthogonium (Busk).

Sertularia orthogonia Busk, 1852, p. 390: Bale, 1884, p. 38.
Synthecium orthogonia Bale, 1888, p. 767.
Synthecium orthogonium Jaderholm, 1903, p. 289; 1916, p. 6: Billard, 1910, p. 23: Bale, 1914*b*, p. 6.
Synthecium campylocarpum Allman, 1888, p. 78: Marktanner-Turneretscher, 1890, p. 248: Campenhausen, 1897, p. 310: Farquhar, 1897, p. 466: Billard, 1910, p. 26: Jaderholm, 1916, p. 6.
? *Synthecium campylocarpum* Inaba, 1890–92, figs. 52–54: Stechow, 1913, p. 127: Jäderholm, 1919, p. 14.

I unite Allman's *S. campylocarpum* with Busk's species, as I am quite unable to find any difference between them. Allman's species, of which I have received a specimen from British Museum, is identical with the form which I figured in 1888 (from the same locality, near Port Jackson) as *S. orthogonium*. I have pointed out in a former paper (1914*b*) that Campenhausen and Marktanner-Turneretscher both state that the forms which they referred to Allman's species resembled *S. orthogonium*, but neither of them gave any reason for not assigning them to that species. Jaderholm (1916) mentions the occurrence of both forms near Cape Jaubert, north-west Australia, and records them as distinct species, without any remarks as to their affinities Billard, again, in his revision of the British Museum Hydroida, refers to the types of the two species, and says nothing as to their relationship. He mentions, however, that Busk's type exhibits the right-angled outward prolongation of hydrotheca as shown in his sketch, copied in my *Catalogue*.

I conclude that these observers regard the abrupt curve outward of hydrotheca and its horizontal continuation as characteristic of *S. orthogonium*. The distinction fails, however, owing to the great variability of the hydrothecae in this particular. On the same branch one often finds hydrothecae bent out abruptly, as in Busk's figure, while in others the curvature is quite gradual. Even in the fragment of Allman's species sent to me one or two hydrothecae are quite similar in this respect to Busk's figure. I have not seen hydrothecae prolonged horizontally quite so far as Busk has shown them, but this prolongation is, in all cases where I have observed it, the result of repeated regenerations. The original aperture is slightly oblique, but when regeneration occurs the new thecostome is advanced slightly more above than below, so that the aperture soon becomes vertical, and the hydrotheca is then continued straight outward.

The "Challenger" figure is unlike type specimens in having aperture at right angles instead of more nearly vertical, and especially in showing hydrothecae as occupying little more than half the height of internode, whereas they really occupy nearly the whole of it (see Billard's figure).

I have mentioned in 1893 that, besides the large gonangia described by Allman, I found on one specimen (from the same gathering) small gonangia, something like those described by Allman as occurring in *S. elegans*, but with the markings more irregular. They are not more than one-third the length of the ordinary ones, and of about the same width. Whether these are the male form or are abnormal is at present doubtful.

The Japanese form figured by Inaba, Stechow, and Jäderholm does not seem to me to belong to this species, but rather to *S. patulum* or to *S. subventricosum*. Goto, in his account of Inaba's species, mentions the subalternate arrangement of the hydrothecae on the proximal portions of the pinnae, a very characteristic feature of the latter species, but also occurring to a much less extent in *S. patulum*.

Loc.—Torres Strait (Busk): near Port Jackson (Bale, Allman): Tahiti (Jaderholm): Auckland (Marktanner-Turneretscher): Ternate (Campenhausen). ? Japan (Inaba, Stechow, Jaderholm).

Synthecium elegans Allman.

Synthecium elegans Allman, 1872, p. 229; 1876, p. 266: Coughtrey, 1874, p. 285: Farquhar, 1896, p. 465: Hilgendorf, 1897, p. 211; 1911, p. 511: Hartlaub, 1901, p. 368. Billard, 1910, p. 25.
Sertularia elegans Coughtrey, 1875, p. 301; 1876, p. 29.
Synthecium ramosum Allman, 1885, p. 137: Billard, 1907*a*, p. 359.

A single specimen from Professor Chilton differs from Allman's figure in having at least the first pair of hydrothecae on the pinnae subalternate instead of exactly opposite; also in having apertures of hydrothecae not quite at right angles, but slightly approaching the vertical.

The locality is unknown; Hartlaub's specimens were from French Pass, Hilgendorf's from Dunedin.

Hilgendorf's remark anent "the close approximation of the opposite hydrothecae which gave the genus its name" is based on a misunderstanding, as the generic name applies solely to the fact that peduncles of gonangia spring from within the cavity of some of the hydrothecae; moreover, opposite hydrothecae in *Synthecium* are not closely approximate.

Allman considered that the peculiarity on which he founded the genus was without parallel in any other group of hydroids, but it is now known to occur as an occasional feature in various hydroids *e.g.*, *Obelia geniculata*, *Sertularella polyzonias*, &c.

Stereotheca zelandica (Gray).

Thuiaria zelandica Farquhar, 1896, p. 464: Billard, 1910, p. 15 (synonymy).
Thuiaria dolichocarpa Allman, 1876, p. 270.
? *Thuiaria hippisleyana* Allman, 1885, p 146.

Allman's magnified figure of *T. dolichocarpa* is quite sufficient for identification, but hydrothecae are shown too rounded; they are tubular, more square at base, with sinus on adcauline side shorter and more abrupt. Hydrotheca has seven teeth, one on apocauline margin and three on each side; in no case were more than seven present, and the only variation I observed was that the two teeth nearest hydrocaulus were in some cases very much reduced, so that there appeared to be only five. A very fine line surrounds hydrotheca a little below margin, and parallel with it.

The specimen sent to me from British Museum consists of a single pinna with a gonangium. So far as I can judge therefrom, the species seems to share with *S. acanthostoma* the very rare character of having both sides of polypidom exactly alike; hydrothecae being no nearer to those opposite them on one side than on the other, and teeth also being symmetrical on the two sides.

If there is an operculum I am unable to trace it in this specimen; probably, as in the other species with numerous teeth, it is inoperculate, and therefore to be referred to *Stereotheca*.

The pinnae are not, as stated, without nodes; in this instance there is one long internode and two or three short ones.

The addition of *T. hippisleyana* to synonyms recorded by Farquhar was made by Billard, who, however, did not see the type of that species According to the figures, the two species are very different, and the specimen of *T. dolichocarpa* sent to me from British Museum shows none of the peculiar features said to characterize *T. hippisleyana*.

Stereotheca huttoni (Marktanner-Turneretscher).

Sertularia huttoni Marktanner-Turneretscher, 1890, p. 233: Farquhar, 1896, p. 463.
? — *Sertularia insignis* Thompson, 1879, p. 109.

Though I have little doubt that *S. huttoni* is only a synonym of the older *S. insignis*, yet as there are certain slight discrepancies in the accounts of the two species, and Thompson's figure does not agree very well with his description, while the gonosome of Marktanner's species is unknown, I content myself at present with noting the similarity of the two forms. *S. insignis* is recorded from George Town, Tasmania; *S. huttoni* from "New Zealand."

Stereotheca elongata (Lamouroux).

Sertularia elongata Farquhar, 1896, p. 461: Bale, 1915, pp. 277, 262 (synonymy).

I have given a pretty full list of references in the above-cited paper. Specimens from Lyttelton, in Professor Chilton's collection, do not differ in any respect from the small form abundant on the southern Australian coast.

Fam. PLUMULARIIDAE.

The genera of the Plumulariidae included in this paper are in accordance with Bedot's classification (*vide* "Notes systématiques sur les Plumularides," *Revue Suisse de Zoologie*, 1921).

Thecocaulus, proposed by me in 1915 as the name of a section of the genus *Plumularia*, comprising the species in which the rachis, as well as the hydrocladia, bears hydrothecae, is adopted by Bedot as a genus. He excludes from it, however, those species in which the hydrocladia produce secondary ramules, also bearing hydrothecae; these he refers to the genus *Schizotricha*, modified from Allman's genus of that name.

Plumularia setacea (Ellis). (Fig. 11.)

Sea-bristles, Ellis, 1755, p. 19.
Corallina setacea Ellis, 1755, pl. xxxviii, p. 19.
Sertularia setacea Linné, 1758, p. 813: Pallas, 1766, p. 148.
Aglaophenia setacea Lamouroux, 1816, p. 171.
Aglaophenia gaymardi Lamouroux, 1824, p. 611.
Plumularia setacea Lamarck, 1816, p. 129: Johnston, 1847, p. 97: Hincks, 1868, p. 296: Bale, 1888, pp. 747, 778; 1919, pp. 348, 349: Farquhar, 1896, p. 466: Hilgendorf, 1897, p. 214: Schneider, 1897, p. 486: Jäderholm, 1896, p. 16; 1909, p. 107; 1919, p. 20: Calkins, 1899, p. 362: Nutting, 1900, p. 56: Hartlaub, 1901, p. 374; 1905, p. 680: Torrey, 1902, p. 79; Billard, 1904, p. 206; 1907*b*, p. 209; 1909*b*, p. 325; 1913, p. 32: Ritchie, 1909, p. 89; 1910*b*, p. 834; 1911, p. 851: Fraser, 1911, p. 84; 1914, p. 209: Hilgendorf, 1911, p. 541: Stechow, 1912, p. 362; 1913, p. 89: Bedot, 1914, p. 86: Broch, 1918, p. 55.
Plumularia multinoda Allman, 1885, p. 157.
Plumularia tripartita v. Lendenfeld, 1884, p. 477.
Plumularia turgida Bale, 1888, p. 779.
Plumularia palmeri Nutting, 1900, p. 65: Fraser, 1911, p. 84.
Plumularia corrugata Nutting, 1900, p. 64: Fraser, 1911, p. 82; 1914, p. 205.

It would serve no useful purpose to cite all the numerous references and the many synonyms applied to this species by the early observers; I may point out, however, that while Bedot and other authors refer to the species as "*P. setacea* Linné," others, including Hincks, quote Ellis as the author of the specific name. Though Ellis, in his text, calls the hydroid "sea-bristles," he also names it "*Corallina setacea*," which seems to be the first use of the specific name.

Billard is the authority for ranking *Aglaophenia gaymardi* Lamouroux as a synonym. I pointed out in 1888 that *P. tripartita* v. Lendenfield was also a synonym. Torrey (1902) added *P. palmeri* Nutting, in which Stechow and Bedot concurred (Bedot 1914).

Bedot, in the above-cited paper, urges that *P. lagenifera* Allman (*P. californica* Marktanner-Turneretscher) and *P. corrugata* Nutting are in no way different from *P. setacea*, and supports this view by figures of several forms of that species observed by him at Roscoff, which, he claims, exhibit the characters which have been ascribed to *P. lagenifera*, &c., such as length, relative and absolute, of hydrocladial internodes, thickness of perisarc, and especially greater or less development of septal ridges. I fully agree that these characters are of little importance But as regards *P. lagenifera* the specific status does not depend upon any of these points, but on the form

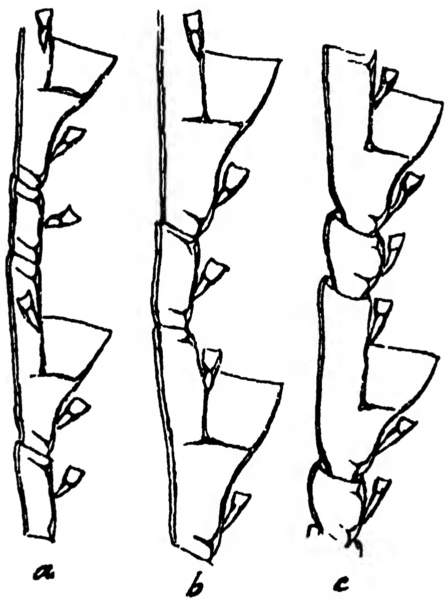

FIG. 11.—*a*, *Plumularia setacea* (Ellis); *b*, *P. setacea* var. – *P. turgida* Bale; *c*, *P. setacea* var. *opima* n. var. × 80.

of the hydrotheca and its internode. The hydrotheca, seen in side view, is almost or quite as wide at base as at rim indeed, the front is often somewhat incurved so that the widest part is at middle. In *P. setacea*, on the other hand, the hydrotheca widens upward from base to margin. The distinction is well seen in Allman's two figures of *P lagenifera* and *P. multinoda* (the latter being only *P. setacea* with septal ridges strongly developed).

I hesitate, therefore, to accept the association of *P. lagenifera* with *P. setacea*. *P. turgida*, however, which I have united with *P. lagenifera* (1919), though undoubtedly intermediate, seems to me now to be more fitly associated with *P. setacea*, judging from numerous specimens of the latter species which I have since obtained. *P. lagenifera* has the anterior mesial sarcotheca borne on a much more pronounced swelling of the internode than any which I have seen in *P. setacea*. None of the figures given by Bedot have hydrothecae at all like those of *P. lagenifera*.

Allman describes both *P. lagenifera* and *P. multinoda* as having hydrothecal internodes separated by several short ones instead of by a single one. I find this character to exist in *P. lagenifera* as an occasional variation only, and it occurs equally in *P. setacea* and *P. caliculata*. The description of *P. multinoda* as having usually five short internodes between two hydrothecal ones is obviously an error. The specimen is one with septal ridges strongly marked, and divisions shown in figure are the two actual nodes, the two ridges always found near ends of the short internode, and the two near ends of hydrothecal internodes. These ridges, encircling interior of internodes, have been mistaken for real nodes. *P. multinoda* is, therefore, only *P. setacea* with well-marked septal ridges.

Here and there, however, in all these species the intermediate internode may be divided by real nodes into two or more shorter ones, and in *P. setacea* I have seen as many as four of these together, only one of them bearing a sarcotheca.

Several examples of *P. setacea* are in this collection, mostly from Lyttelton; one from Sumner had hydrothecae slightly larger than the others. Also recorded from Timaru by Hilgendorf, from Sumner by Hartlaub, from Quail Island by Chilton, and from Tauranga by Allman. Professor Chilton's Sumner specimen, which is of somewhat larger proportions throughout than typical forms, corresponds exactly with that which I formerly described as *P. turgida*, and which was among von Lendenfeld's types in the Australian Museum, labelled "*P. aglaophenoides*"; it came from Lyttelton.

Plumularia setacea var. opima n. var. (Fig. 11, *c*.)

This form resembles *P. setacea* in its general characters, but is of larger proportions throughout than typical forms. Hydrothecal internodes are swollen out more abruptly below hydrothecae, as in *P. lagenifera*, but the latter are not, as in that species, as wide at base as at summit.

Internodes of hydrocladia are very stout in proportion to length, the intermediate ones especially being often nearly or quite as wide as long, but they are rounded off at ends to a small diameter, so that nodes are very deeply constricted, a feature which gives the variety a characteristic appearance.

Gonangia large, and borne profusely at bases of hydrocladia throughout greater part of the colony. The only complete specimen was about 40 mm. in length; it was collected at Tomahawk Beach, Dunedin, by Mr. C. B. Morris. Specimens, also from Dunedin, are in Professor Chilton's collection.

Plumularia wattsi Bale. (Fig. 12.)

Plumularia wattsi Bale, 1886, p. 95.

P. wattsi has not been recorded since I described it in 1886 from Port Phillip, and another specimen given to me by the late Dr. MacGillivray was probably from the same locality. In Professor Chilton's collection are fragments from Port Chalmers.

My original specimen was about 10 in. high, and was incomplete, the upper portion having been torn off, and replaced by irregular regeneration-growth. The slender monosiphonic stem is divided into internodes of from 0·7 mm. to 1·5 mm. in length, with an average thickness of about 0·25 mm., the longer and shorter ones interspersed irregularly, and each internode

supporting a small branch close to the top. These branches are arranged in an irregular spiral, are mostly under 1 in. in length, and sometimes give origin to one or two secondary branches. The structure of each individual branch corresponds closely with that of a complete shoot of *P. setacea*, the hydrothecae and sarcothecae, with the general arrangement of the hydrocladia, being quite similar in the two species. The gonangia also resembles those of *P. setacea*, though the few which I observed were rather smaller, and very thin and delicate. The perisarc of main stem is very thick, equalling about one-fourth of diameter. The branches mostly have the first long internode borne directly on the apophysis, but sometimes there is a short intervening internode without a hydrocladium. In older portions, however, the first two or three internodes of branches may be very irregular, the result apparently of repeated regenerations.

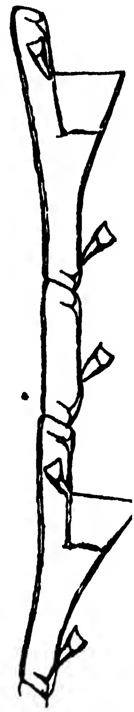

FIG. 12.
Plumularia wattsi Bale.
× 80.

Professor Chilton's specimens were very small pieces, not including more than ¼ in. of stem. The stem-internodes varied from 0·7 mm. to 1·0 mm. in length, and averaged about 0·2 mm. in diameter, with thinner perisarc than my original specimen. On each were four sarcothecae, one at each side of branch (these two converging towards each other in axil), and two in line, one about one-fifth and the other about three-fifths of the length of internode from base.

In the original specimen I had not observed these sarcothecae, but on a close search I found two or three remaining, also several scars indicating where others had fallen off. This, judging from the thick perisarc, was an old specimen, and it appears that when sarcothecae were lost they were not replaced (as were the branches), and that the channels communicating with them had been more or less filled up with perisarc.

Dr. MacGillivray's specimens closely resemble those from New Zealand, the only difference I noticed being that the stem-internodes in some cases supported three sarcothecae in line instead of two.

Thecocaulus heterogona n. sp. (Fig. 13.)

Shoots growing in clusters, reaching about 6 in. in height, stems stout, monosiphonic, unbranched, pinnate, joints very oblique, a hydrocladium and a hydrotheca on each internode. Hydrocladia alternate, both series springing from the front, joints oblique, internodes short, a hydrotheca on each except the first two.

Hydrothecae set at an angle of about 45°, large, campanulate, free at the back, free part somewhat concave, margin entire.

Sarcothecae bithalamic, canaliculate, more or less movable, one on each side of hydrotheca (except the cauline ones), one in front, curved forward, one on second internode of each hydrocladium, two abreast above each cauline hydrotheca.

Gonangia, female, very large, ovate, tapering below, membranous, borne on stem at side of hydrothecae, with a pedicel of about two short joints; several large sarcothecae around base: male, very small, ovate, borne on hydrocladia at sides of internodes just below hydrothecae, not provided with sarcothecae.

Loc.—Cape Maria van Diemen, ten miles north-west, 50 fathoms. (Chilton.)

From its general habit this species might at first sight be taken for *P. buski*, from which species, however, it differs widely in many of its structural details. The cauline hydrothecae are borne on very stout processes of stem, and from sides of these processes spring the hydrocladia, which commence by an extremely short internode, followed by a

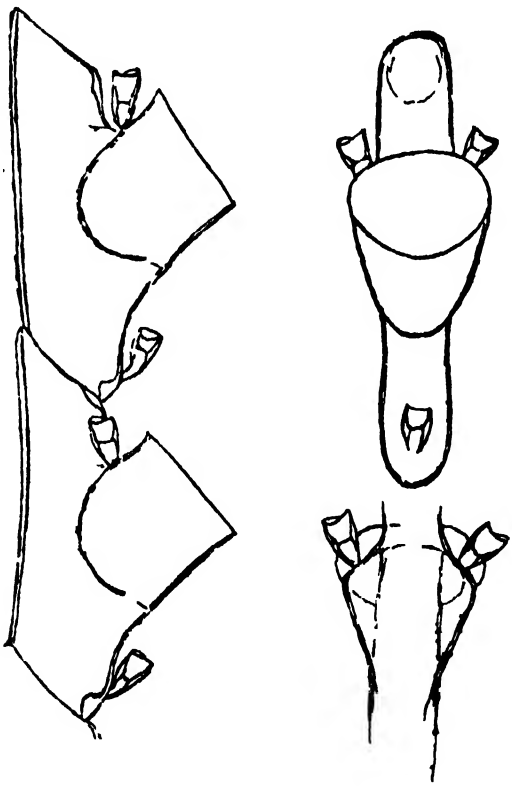

FIG. 13.—*Thecocaulus heterogona* n. sp. × 80.

rather longer one, bearing a sarcotheca; the rest are alike, no intermediate ones being normally present, and no sarcothecae except the usual three surrounding each hydrotheca. As in the allied species generally, however, the hydrothecal internode may have a faint transverse constriction just above hydrotheca. Hydrothecae like those of *P. buski*, but the free part of back is slightly concave, as in *P. concava* Billard. In the condition of the anterior sarcothecae the species is a marked exception to the general rule in *Thecocaulus*. Instead of the stout, rigid, curved process usually seen, we have here a narrow-based form, not very different from

laterals, though still apparently somewhat less freely movable. Internodes are considerably expanded laterally at back of hydrothecae, enlargements so formed taking the place of the more definite peduncles found supporting the paired sarcothecae in most species. The pairs of sarcothecae on rachis are not attached to hydrothecae, but situated a little distance above them, and the regular supracalycine pair are wanting.

Male and female gonangia may be found on same shoot. The former are remarkably small, being but little longer than hydrothecae, and only about half their diameter. They differ from those of most allied species in the total absence of sarcothecae. The female gonangia, on the other hand, are extremely large (about 2·5 mm. by 0·8 mm.), and excessively thin and delicate, shrivelling up at once if placed suddenly into a dense medium. In the two specimens which I observed I could just trace a faint circular suture at the tops, but no thickened border. One had four large sarcothecae round base; on the other I found only two, but possibly others had become detached.

Aglaophenia plumosa Bale.

Aglaophenia plumosa Bale, 1881, p. 37; 1884, p. 153: Bedot, 1921*a*, p. 337. Not *A. plumosa* Pennington, 1885, p. 129.

Quail Island (Chilton). Not previously recorded from New Zealand.

Aglaophenia filicula Hilgendorf.

Aglaophenia filicula Hilgendorf, 1897, p. 215.

Hilgendorf refers this form to *A. filicula* Allman, which is classed by Bedot as a synonym of *A. tubulifera* Hincks. The species is indeterminable; Hilgendorf's description would apply equally to many other species, and the figures are not sufficient to serve for identification.

Aglaophenia incisa Coughtrey.

Plumularia incisa Coughtrey, 1874, p. 290.
Aglaophenia incisa Coughtrey, 1876, p. 31: Farquhar, 1896, p. 467.

This is an indeterminable species from Lyall Bay. It may possibly be the same as *Halicornaria rostrata* n. sp., as it has the front of hydrothecae produced into a pointed rostrum, as in that species.

Aglaophenia huttoni Coughtrey.

Plumularia banksii Hutton (not Gray), 1872, p. 259.
Plumularia huttoni Coughtrey, 1874, p. 290.
Aglaophenia huttoni Coughtrey, 1876, p. 31: Farquhar, 1896, p. 467.

Another indeterminable species from Lyall Bay. It is, according to Hutton, irregularly branched, polysiphonic, with alternate pinnae leaning to one side: its hydrothecae have a pointed rostrum, as in *A. incisa*. It is said to have the aperture "sinuous and wide, with an obtuse tooth on each side," but Coughtrey's figure shows several crenations on each side of hydrotheca. Evidently the "obtuse tooth" refers to lateral sarcotheca. From the inadequate figure it might be supposed the same as *Thecocarpus formosus;* its polysiphonic and branching habit, however, seem to forbid the association.

Aglaophenia huttoni Kirchenpauer.

Plumularia pennatula Hutton (not Ellis and Solander), 1872, p. 258: Coughtrey, 1874, p. 289.
Aglaophenia pennatula? Coughtrey, 1876, p. 31.
Aglaophenia huttoni Kirchenpauer, 1876, p. 24: Farquhar, 1896, p. 467 (note).

Another species from Lyall Bay, also indeterminable. The hydrothecae, with their long slender sarcothecae, resemble those of *Halicornaria*

longirostris Kirchenpauer, but the gonosome is said to include a corbula. I do not know any corbula-bearing species with hydrothecae of this type.

Investigation at Lyall Bay might probably result in the discovery of specimens of these insufficiently-described forms, especially the present species, which is said to be common. If identified with reasonable probability it should be renamed, as the specific name *huttoni* was first used by Coughtrey for the preceding species (unless the two species should prove to belong to different genera).*

Aglaophenia acanthocarpa Allman. (Fig. 14.)

> *Aglaophenia acanthocarpa* Allman, 1876, p. 274 : Farquhar, 1896, p. 467.
> *Aglaophenia laxa* Hilgendorf, 1911, p. 541.
> ? *Aglaophenia divaricata* var. *acanthocarpa* ? Jäderholm, 1916–17, p. 18.
> Not *A. divaricata* var. *acanthocarpa* ? Bale, 1915, p. 313.
> Not *A. laxa* Allman, 1876, p. 275.

Hydrophyton slender, polysiphonic, branched, branches springing from the supplementary tubes. Hydrocladia close, alternate, one on each internode, rising at an angle of 40–45°, and strongly directed forward; nodes oblique.

Hydrothecae urceolate, deep, set at angle of about 40–45°, a rudimentary ridge a little below middle of adcauline side, with a fold from it nearly surrounding hydrotheca; border with four teeth on each side, the first wide, second and third triangular, fourth minute or obsolete, only the second everted; a median anterior tooth with erect crest; back adnate. Hydrothecal internode with strong transverse septal ridge near middle, and oblique one near base of lateral sarcothecae. Hydropore very large.

Mesial sarcotheca a little longer than hydrotheca, adnate to it as far as margin, and then projecting outward, free part forming a tube nearly equal in diameter from lateral aperture to end, and bent forward, with distinct terminal and lateral apertures, and an orifice opening into hydrotheca. Lateral sarcothecae adnate up to hydrotheca-margin, with a short free part directed forward, usually becoming much larger towards ends of hydrocladia; terminal and lateral apertures distinct. Cauline sarcothecae wider than laterals, two on rachis at base of each hydrocladium.

Gonangial pinna replacing a hydrocladium, the first internode bearing a hydrotheca. Corbula open, with about 15–20 strongly-arched pinnules on each side, each springing from a separate internode of rachis, and furnished with two lateral series of long slightly-curved tubular sarcothecae, the two proximal ones on distal side of each pinnule without corresponding ones on the other side, and the first one often bifid, and with a small secondary one; nodes between pairs of sarcothecae usually indistinct. Two sarcothecae on rachis at base of each pinnule.

Specimens from British Museum enable me to identify this species with the form from Kermadec Islands collected by Mr. W. R. B. Oliver and described by Hilgendorf as *A. laxa* (specimens of which were given to me by Mr. Briggs). They also indicate that the form described by me as *A. divaricata* var. *acanthocarpa* is not the same as Allman's species.

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* Stechow in a recent paper in *Archiv fur Naturgeschichte*, 1921, proposes the name *Aglaophenia zelandica*. But in the very possible event of the two species being identified as of different genera the specific name *huttoni* may stand for both species.

The following characters distinguish the species from *A. divaricata.* In the latter the base of hydrotheca is broadly rounded and deeply immersed, while the lower part of hydrotheca, from intrathecal ridge to base, is quite continuous with cavity of internode, the usual partition being absent. In *A. acanthocarpa* the base of hydrotheca is narrower, not so deeply immersed, and the partition between hydrotheca and internode is present, though in front view it can be seen to consist only of a quadrangular diaphragm, formed by a narrow shelf bordering the intrathecal ridge, the two sides, and base of hydrotheca. The mesial sarcotheca in *A. divaricata*, as seen in side view, tapers towards end (though in front view it becomes wider); in *A. acanthocarpa* that part of the sarcotheca in which the lateral aperture is situated stands off from the hydrotheca almost at a right angle, but above the aperture the sarcotheca is tubular, not compressed nor widened, bent forward, and nearly or quite uniform in diameter to end, exactly as in Allman's figure of *A. laxa.* The first pair of lateral teeth of hydrotheca are very broad and obtuse, and in profile they usually overlap anterior tooth, which has

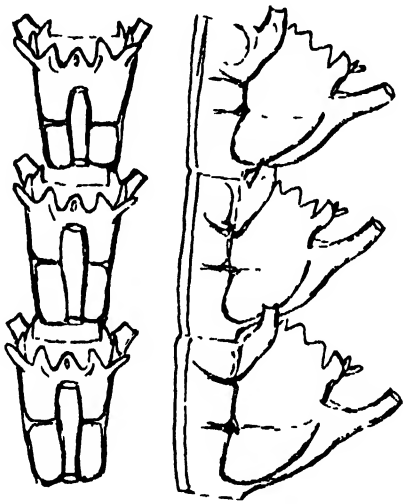

FIG. 14.—*Aglaophenia acanthocarpa* Allman (from a Kermadec Island specimen). × 80.

an erect keel or crest like that of *A. mccoyi.* Last pair of lateral teeth very small, and not generally apparent in profile view. The orifice between mesial sarcotheca and hydrotheca is rather large, easily seen in side view. Intrathecal ridge reduced to narrowest dimensions; two septal ridges are as shown by Allman. Lateral sarcothecae become much larger towards ends of hydrocladia (a character seen even more conspicuously in some forms of *A. divaricata*). Hydrothecae, like the whole polypary, are smaller and more delicate than those of *A. divaricata* and its varieties. This is especially the case with Kermadec specimens. Allman, like Jäderholm, gives no indication of erect crest on anterior tooth, which is well developed; and Jäderholm shows the first pair of lateral teeth as narrow and pointed in side view, and widely separated from median one—in other respects his figure agrees well with my specimens.

Allman's figure of corbula is rather misleading as to its general aspect. The ribs are very strongly curved, so that in a direct profile view only the middle part of them can be seen distinctly, not only on account of difference in focus, but of extreme foreshortening of upper and lower portions. The figure is more like what the corbula would be if it were compressed till the curvature of the ribs should be very nearly straightened out. This applies to Hilgendorf's figure also.

The only corbula seen by me in the Kermadec Island specimen was, like Hilgendorf's, very short, being probably incomplete. Sarcothecae on proximal portions of corbula-ribs are quite regularly arranged, the first two internodes having them on distal side only. In this, as in other respects, corbulae agree with those of *A. divaricata.*

Aglaophenia laxa Allman. (Fig. 15.)

Aglaophenia laxa Allman, 1876, p. 275: Farquhar, 1896, p. 467.
Not *A. laxa* Hilgendorf, 1911, p. 541.
Not *A. laxa* Stechow, 1907, p. 199; 1909, p. 93.
Not *Thecocarpus laxus* Billard, 1913, p. 98.

Of this species, which is closely allied to *A. acanthocarpa*, I have also received specimens from British Museum. It is described as a smaller form than *A. acanthocarpa*, and of more open habit, the hydrocladia

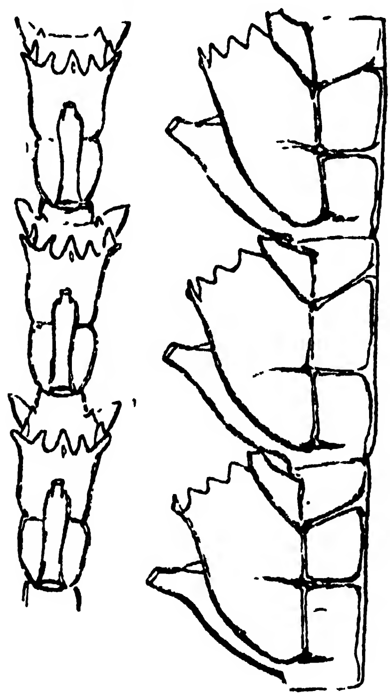

Fig. 15.—*Aglaophenia laxa* Allman (from one of Allman's specimens). × 80.

being somewhat less close. The internodes and hydrothecae are not shorter, as shown in Allman's figure; on the contrary, 6 complete internodes of *A. laxa* are about equal in length to 7¾ of those of

A. acanthocarpa. This is due partly to the actual length of hydrothecae, and partly to their forming a lower angle with internode. The first lateral tooth is not so wide as in *A. acanthocarpa*, and the anterior tooth has a small semicircular crest instead of the longer one of the other species. The mesial sarcothecae of both species are just as Allman has figured them in *A. laxa*, except that they are sometimes shorter; in many cases, especially in proximal portions of hydrocladia of *A. laxa*, they are cut down close to lateral aperture. The first two septal ridges are as in *A. acanthocarpa*, the forward one being usually more oblique than Allman shows it; the third one, opposite base of hydrothecae, is generally much less pronounced. The orifice between mesial sarcotheca and hydrotheca is very small, and not noticeable in side view. The opening between hydrotheca and internode is much as in *A. acanthocarpa*, but the shelf-like border is slightly narrower.

The *Thecocarpus laxus* of Billard is readily distinguishable from this species, even in the absence of corbula. In *T. laxus* intrathecal and septal ridges are much nearer base of hydrotheca, and therefore farther from ridge at base of lateral sarcothecae, and the extreme base of hydrotheca does not dip so deeply into internode as the part farther forward, the condition being the opposite in *A. laxa.* The third ridge is not present in *T. laxus.* In *A. laxa*, as in all the *divaricata* group, the second lateral tooth of hydrotheca is notably everted, and the others not at all; in Billard's species the third is widely everted, and the second but little everted, or even incurved

Hilgendorf's "*A. laxa*" is, as mentioned elsewhere, *A. acanthocarpa.*

Specimens referred to *A. laxa* by Stechow, which had only two shallow triangular lobes on each side of hydrotheca, were afterwards regarded by him as *A. whiteleggei.*

The gonosome of *A. laxa* is not yet known, but the close affinity between the species and *A. acanthocarpa* and *A. divaricata* renders it highly probable that it will prove to be of the same character as in those species.

Thecocarpus formosus (Busk).

Plumularia formosa Busk, 1851, p. 118.
Aglaophenia formosa Allman, 1871, p. 157: Kirchenpauer, 1872, p. 26: Bale, 1884, p. 168: Marktanner-Turneretscher, 1890, p. 264: Farquhar, 1896, p. 467.
Thecocarpus formosus Billard, 1907*a*, pp. 378, 385: Stechow, 1912, p. 370; 1919*a*, p. 143: Bedot, 1921*a*, pp. 333, 322.
Not *Aglaophenia formosa* Bonnevie.

It is perhaps doubtful whether all the above-cited references are to the same species. That described by Billard has a closed corbula, but Kirchenpauer, as mentioned by Billard, has figured the corbula as open. Possibly, as in several cases now known, this may be a difference of sex, otherwise it would seem that these observers have seen two different species. Busk's reference to the corbulae as costate capsules seems most appropriate to the closed form.

Allman referred to the species as being known to him from Australia, New Zealand, and South Africa, and Billard adds Madagascar and Ceylon. I have never met with the species in collections from Australia or New Zealand.

Thecocarpus chiltoni n. sp. (Fig. 16.)

Hydrophyton polysiphonic, pinnately branched, branches in one plane, alternate, subregular, rising at an angle of about 45° from the primary

stem, each taking the place of a hydrocladium. Hydrocladia close, alternate, at about 15°, one on each internode, both series directed a little forward.

Hydrothecae at an angle of about 40°, deep, widened upward from base; a very narrow intrathecal ridge near base on adcauline side, with a fold from it crossing hydrotheca and curving slightly forward; aperture with short anterior tooth, above which the front is produced into a somewhat longer point; lateral teeth 4 on each side, the first and fourth very minute, often obsolete, second and third nearly triangular, shallow: back adnate. Internode with short septal ridges opposite the intrathecal ridge and the bases of the lateral sarcothecae.

Mesial sarcotheca a little shorter than calycle, and mainly rising from it, tapering, canaliculate. Lateral sarcothecae tubular, adnate to hydrotheca nearly to margin and then bent forward, canaliculate. Cauline sarcothecae canaliculate, two at base of each hydrocladium, the lower projecting forward, the other larger, projecting outward.

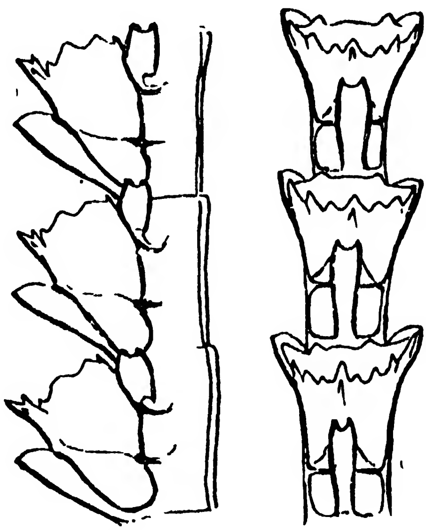

FIG. 16.—*Thecocarpus chiltoni* n. sp. × 80.

Gonangial pinna replacing a hydrocladium, with the first two internodes bearing hydrothecae. Corbula curved, rather short, consisting of about 8 pairs of alternate ribs, originating as narrow pinnules but expanding above into broad leaflets, which unite to form corbula; distal margin of each leaflet bordered with about 5 7 tubular, closely-set sarcothecae; a stout spur springing from distal side of each leaflet, just above base, bluntly pointed or with alternate sarcothecae, and bearing a small modified hydrotheca with lateral sarcothecae.

Loc.—Cape Maria van Diemen, ten miles north-west, 50 fathoms (Chilton).

The specimen has two main stems, reaching about 8 in. in length, and about 8 mm. in diameter at base, clothed almost down to base with branches, which reach about 3 in. in length, and are alternate, the average distance between successive branches on the same side being about ¼ in. Being all in one plane, the colony somewhat resembles that of

Lytocarpus phoeniceus, except that the branches are alternate instead of opposite. Secondary branches sometimes occur.

The two hydrothecae on gonocladium do not differ appreciably from the others, but those on corbula are smaller, more cylindrical, with intrathecal fold more oblique, marginal teeth smaller, and anterior one without superior point. Only male corbulae present.

Hemicarpus banksi (Gray). (Fig. 17, *a*.)

Plumularia banksii Gray, 1843, p. 294: Coughtrey, 1874, p. 280.
Aglaophenia banksii Bale, 1886, p. 103: Farquhar, 1896, p. 467.

Ever since Gray's time this has remained an unidentifiable species, Hutton's reference to it of a hydroid found by him at Lyall Bay being pronounced by Coughtrey to be erroneous. By the aid of a fragment of Gray's specimen received from British Museum I am enabled to give

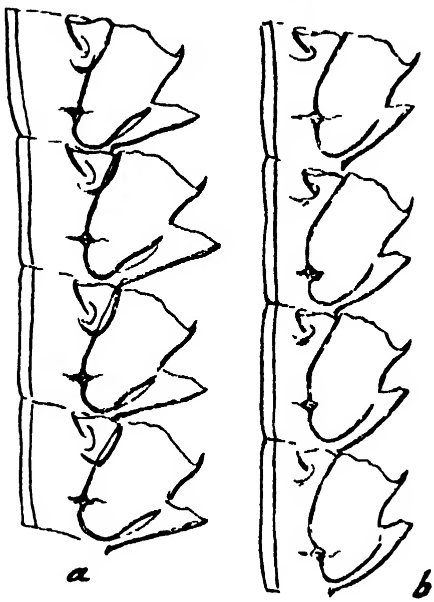

FIG. 17.—*a*, *Hemicarpus banksi* (Gray), from Sir Joseph Banks's specimen; *b*, *Lytocarpus secundus* Allman, from one of Allman's specimens. × 80.

an account of it sufficient to render its identification possible. Though its gonosome is not present, its close similarity to *Hemicarpus secundus* (*Aglaophenia secunda* Kirchenpauer, *Lytocarpus secundus* Allman), which Bedot unites with the *Sertularia pennaria* of Linné, leaves no doubt as to the affinity of the two forms, and in fact it is not certain that they are even specifically distinct.

Gray mentions that the stem is compound and branched; his description of branchlets as opposite is, however, not in accordance with the specimens, which, Captain Totton informs me, have the branches alternate, pinnately arranged, pinnae being at distances of from 5 mm. to 8 mm. apart, and both series directed strongly to front (Gray describes them as unilateral). The specimens, which are fragmentary, measure about 38 mm. and 35 mm. respectively.

The slide sent to me contained half a dozen hydrothecae, very well preserved. They are notably small for Statoplea, subconical, rather narrowed-in between mesial sarcotheca and margin, with a rudimentary ridge on adcauline side near base, from which originates a very small sharply-defined fold of hydrotheca-wall, curved or sigmoid; sides are more prominent than front and back, and margin has small undulations or crenations which are quite irregular, even those on the two sides not corresponding. So far as I can judge from the side view, the back appears adnate. In front is a strong thick conspicuous median tooth, somewhat incurved, which, as seen in strictly lateral view, projects quite abruptly. (The condition is the same in *H. secundus*, the sides not curving gradually into median tooth, as shown by Allman.)

Anterior sarcotheca a little shorter than hydrotheca, but more projecting, and adnate to hydrotheca rather more than half the length of the latter; the free part is widely open in front, and each side forms a wide angular lobe. There is a small orifice connecting cavity of hydrotheca with that of sarcotheca. Lateral sarcothecae short and very wide, with the whole front margin free. Opposite intrathecal ridge is a very narrow thickening in internode, which shows sufficient variability to warrant the surmise that it may be sometimes extended into an annular ridge.

In a slide of portions of the "Challenger" specimen of *H. secundus*, sent for comparison, are a considerable number of hydrothecae, which differ very little from those of *H. banksi*. The most noticeable points of difference are that in *H. banksi* there is a distinct bulging inward of the front of hydrotheca under mesial sarcotheca, which is not seen in *H. secundus*, and that mesial sarcotheca in the former species is more projecting.

Whether the differences are sufficiently constant to justify the retention of *H. banksi* as a separate species cannot be determined until further material is available.

Halicornaria rostrata n. sp. (Fig. 18.)

Hydrocaulus monosiphonic, unbranched; hydrocladia alternate, not close, one on each internode, at an angle of about 45°, both series directed forward; nodes oblique.

Hydrothecae at an angle of about 40°, very narrow at base and widening upward, a narrow rudimentary intrathecal ridge on adcauline side near base, hydropore on adcauline side at base, with several chitinous points on distal margin (over ridge); front of hydrotheca produced into a large hollow pointed rostrum with entire apex, extending much beyond aperture; margin with incurved anterior tooth, and three triangular teeth on each side, the first and third everted, the second incurved, and two minute angular lobes behind lateral sarcothecae; back entire, adnate. Internode with a thickened ridge opposite distal edge of hydropore, sometimes extending partly round.

Mesial sarcotheca about as long as body of hydrotheca, mainly rising from it and adnate more than half its length; free part canaliculate, slightly recurved towards end. Lateral sarcothecae stout, saccate, canaliculate, adnate up to margin of hydrotheca, and directed strongly outward. Cauline sarcothecae canaliculate, two at base of each hydrocladium in front and one behind each axil.

Gonosome ?

Loc.—Cape Maria van Diemen, ten miles north-west, 50 fathoms (Chilton).

This species is referred to *Halicornaria* on account of the monosiphonic habit, the presence of a cauline sarcotheca at back of each axil, and the little points bordering hydropore – all special characteristics which I have not found combined in any species known to belong to other genera.

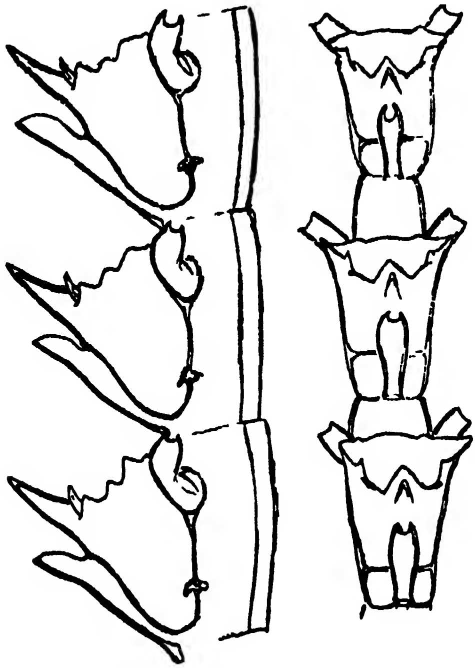

FIG. 18.—*Halicornaria rostrata* n. sp. × 80.

The peculiar character of the prolongation of front of hydrotheca into a rostrum much exceeding mesial sarcotheca in length is found both in *P. huttoni* and *P. incisa*, figured by Coughtrey. The former is a polysiphonic species, but *P. incisa* is monosiphonic, and may quite possibly be identical with the present species.

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*Some New Zealand Amphipoda: No. 4.**

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[*Read before the Philosophical Institute of Canterbury, 6th December, 1922; received by Editor, 31st December, 1922; issued separately, 18th June, 1924.*]

Seba typica (Chilton).

Seba typica Chilton, 1906, p. 572; 1921, p. 56. *S. saundersii* Stebbing, 1906, p. 163 (part).

Specimens which I have referred to this species were taken by the F.I.S. "Endeavour" off the east coast of Flinders Island, Bass Strait. The largest of these were about 4·5 mm. long, and were apparently fully developed males. In them the palm of the second gnathopod was distinctly oblique, and the basal and meral joints of the fifth peraeopod widely expanded posteriorly. Smaller specimens have the palm transverse and the meral joint only slightly expanded. Although there was no female bearing eggs in the collection, there were specimens in which the first gnathopod was distinctly chelate, the palm being on a projecting portion of the propod against which the finger impinges; these I considered to be females, or very young males not yet differing in structure from females. Other specimens showed transitional forms between the chelate limb and the subchelate gnathopod with oblique palm; some of them had the palm quite transverse.

In February, 1922, I collected from seaweed exposed at low tide at Kaikoura three small specimens about 3 mm. long. One of these proved to be a female bearing two large eggs in the brood-pouch; it had the first gnathopod chelate, as described in my original account, and the joints of the fifth peraeopod not expanded. The other two bore no eggs, but were otherwise similar, though slightly smaller.

It is very probable that all the forms of *Seba* described under different names really belong to one species. Walker, however, describes the males of *S. antarctica* as dimorphic, one form being like the females, the other differing in having the joints of the fifth peraeopod greatly expanded but having the first gnathopod chelate as in the females. Walker's first form of male is, I think, only an immature stage of the second form; while the latter, if fully mature, differs from the Australian specimens in still having the first gnathopod chelate. It is possible, however, that it is not fully developed, and has not yet attained the oblique palm of the male, though it has the joints of the peraeopod expanded. The largest male—*i.e.*, the one of which Walker gives a full figure—was 7 mm. long, and therefore larger than specimens from Bass Strait having oblique palms; but the Antarctic specimens probably grow to a much larger size than those found farther north, and the specimen may not be mature though 7 mm. long. This supposition appears to be confirmed by the fact that the second male examined by Walker is 5 mm. long, but has the peraeopod joints less expanded than in Australian specimens, which are slightly smaller.

* Previous numbers of this series have appeared in *Trans. N.Z. Inst.* as follow: No. 1, vol. 52, p. 1; No. 2, vol. 53, p. 220; No. 3, vol. 54, p. 240.

Stenothoe valida Dana.

Stenothoe validus Dana, 1853 55, p. 924, pl. 63, fig. 1, *a–o*. *S. valida* Stebbing, 1906, p. 194; Walker, 1910, p. 621; Kunkel, 1910, p. 16; Chevreux, 1913, p. 3. *S. valida* (part) Della Valle, 1893, p. 566, pl. 58, figs. 74–78; Chilton, 1923, p. 95. *S. adhaerens* Chilton, 1892, p. 259 (? not Stebbing, 1888, p. 1999). *S. assimilis* Chevreux, 1908, p. 4; Walker, 1910, p. 621. *Montagua miersii* and *M. longicornis* Haswell, 1880, p. 323, pl. 24, figs. 4, 5. *Montaguana miersii* Chilton, 1883, p. 79. *Probolium miersii* Chilton, 1885, p. 1043. *Stenothoe miersii* Stebbing, 1906, p. 200. ? *Stenothoe dollfusi* Chevreux, 1887, p. 327; 1891, p. 260 Stebbing, 1906, p. 196.

This species is common on the New Zealand coasts, and I have series of specimens from several localities. There are great differences in the length of the antennae, especially of the second antenna, and in the shape of the gnathopods, due to age and sex. In the more mature males the second antenna increases very considerably in length, especially in that of the peduncle, and the second gnathopod becomes very large and assumes the form shown in Chevreux's figure of *S. assimilis*. In addition to this form and the variations in it which are presumably due to age, there is another in which the teeth at the distal end of the palm of the second gnathopod project more or less at right angles to the palm, instead of being a continuation of it as in the first form. This second form appears to be identical with the one described by Chevreux under the name of *Stenothoe dollfusi*, and it is apparently this form that Kunkel had before him when recording *Stenothoe valida* from the Bermudas. As I have found the two forms *Stenothoe valida* and *S. dollfusi* together on two separate occasions in Cook Strait, and as both forms also occur together in Port Jackson, New South Wales, and apparently elsewhere, I have little doubt that they both belong to one species, and that we have here another example of a species with dimorphic males.

In the older males the mouth-parts appear to become degenerate. I have, however, discussed this question more fully, and also the reasons for referring the species to the one originally described by Dana, in the *Records of the Australian Museum*, vol. 14, p. 95.

I have recently received specimens from the Hawaiian Islands which appear to belong to this species.

Localities.–Lyttelton; Dunedin Harbour; Cook Strait.

Distribution.–Australia; North and South Atlantic Oceans; Hawaiian Islands.

Bovallia monoculoides (Haswell).

Bovallia monoculoides Chilton, 1909, p. 622; 1912, p. 494; 1921, p. 66. *Eusiroides monoculoides* Chevreux, 1908, p. 478; Stebbing, 1910, p 595; Barnard, 1916, p. 174. *Eusiroides caesaris* Walker, 1904, p. 264.

In 1909 I referred to this species specimens from the Auckland Islands; but it has not hitherto been recorded from the coasts of the main islands of New Zealand. I have now, however, in my collection numerous specimens from different localities extending from the Three Kings to Otago Harbour.

These are all much smaller than the specimens from the Auckland Islands, none of them measuring more than about 8 mm. in length, but they

agree closely with specimens of similar size from Port Jackson, New South Wales, the type-locality. In none of them are any of the segments produced into definite dorsal teeth, but all have the posterior margin of the third pleon segments serrate, as described by Stebbing for *Eusiroides caesari*, though in one or two instances the teeth are rather indistinct, thus approaching the condition found in *E. crassi*.

The species has been recorded from South Africa by Barnard, from Ceylon by Walker, and from the Gambier Archipelago by Chevreux. Of the two specimens from the latter locality, one was a female bearing young, though only 4 mm. in length. Of them Chevreux says, "Chez ces exemplaires, le bord postérieur des plaques épimérales du dernier segment du métasome, moins convexe que chez le type, ne présente que des crénelures peu distincts."

If *Bovallia gigantea* Pfeffer is considered as belonging to the same species, corresponding to the form described by Stebbing under the name *Eusiroides crassi*, then the range of the species is extended to the subantarctic and antarctic seas to the south of South America.

I have been able to compare my New Zealand specimens with examples of *Eusiroides della-vallei* Chevreux from Banyuls-sur-mer, on the south coast of France, and can find little difference between the two.

Localities.—Off Three Kings, 60 65 fathoms (Chilton); Cook Strait cable, off Oterangi Bay (H. B. Kirk); Cook Strait cable (Captain J. W. Grey); north-west of Cape Maria van Diemen, 50 fathoms (Chilton); Moeraki, east coast Otago (Chilton); Otago Harbour, surface (G. M. Thomson); Lyttelton Reef (R. M. Laing); Lyall Bay (R. M. Laing).

Chiltonia mihiwaka Chilton.

Chiltonia mihiwaka Stebbing, 1906, p. 555: Chilton, 1909A, p. 644; 1909B, p. 57.

This species was described from specimens obtained in streams on Mount Mihiwaka, near Port Chalmers, at heights up to about 1,000 ft. above sea-level. Later on Mr. G. M. Thomson collected it in similar localities on Mount Maungatua and other hills in the neighbourhood of Dunedin. During the expedition of the Philosophical Institute of Canterbury to the Subantarctic Islands of New Zealand in 1907, specimens were taken in fresh-water pools and streams on Enderby Island, Auckland Island, and Campbell Island, at places not far above sea-level. These specimens differed from the type in having the palm of the second gnathopod in the male oblique instead of transverse, and prove to be the same as *C. subtenuis* Sayce, a species found in New South Wales, Victoria, and Western Australia.

In December, 1922, I found two specimens, male and female, *in coitu*, in a small fresh-water stream at Riverton, Southland, just about high-water mark. It was low tide at the time, and the water in which the animals were living was quite fresh, but the sea water would reach the place at high tide. Both specimens were deeply pigmented of a dark-grey colour, while the Port Chalmers specimens are usually much lighter, some being almost white. The Riverton specimens resemble those from Mount Mihiwaka so much that they must be considered as belonging to the same species, but there are some slight differences. The second gnathopod of the male (fig. 1)* has the palm quite transverse, and the dactyl has a rounded

* The illustrations for this paper were drawn for me by Miss Beryl Parlane, one of my students.

lobe on the concave margin towards its base which is not found in the type. In the male specimen the first or upper antennae are distinctly shorter than the second, while in the type they were of equal length. In the Enderby and Auckland Islands specimens the first antennae are considerably longer than the second. The relative lengths of the antennae in a few of the specimens in my collection are shown in the diagram given below, the first being represented by unbroken lines, the second by dotted

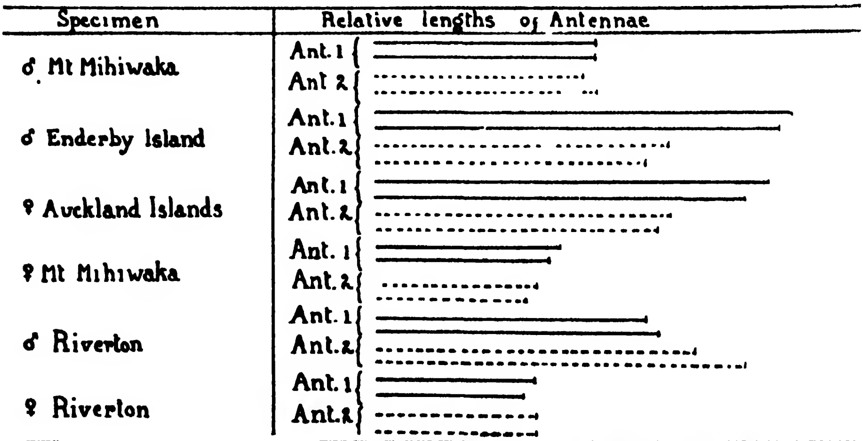

Table showing relative lengths of the antennae in different specimens of *Chiltonia mihiwaka.*

lines. It will be seen that the antennae vary in length on the two sides, and in specimens from different localities. The generic diagnosis given by Stebbing (1906, p. 555), which says "Antennae 1 and 2 equal in length," must be altered to "Antennae 1 and 2 nearly equal in length."

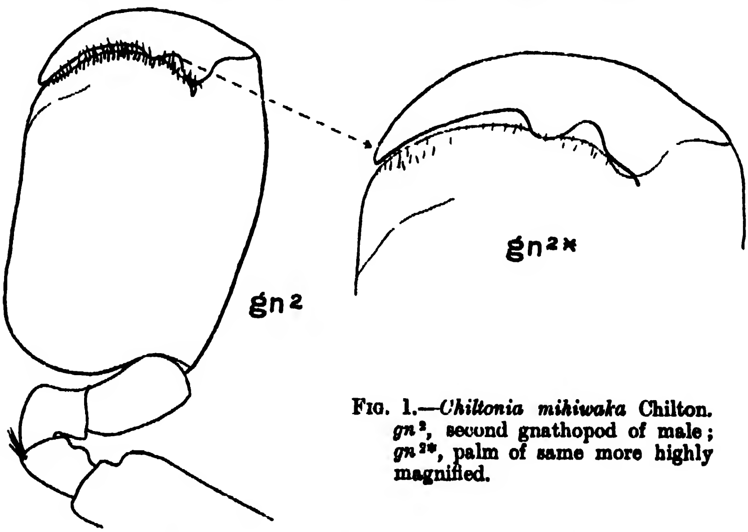

FIG. 1.—*Chiltonia mihiwaka* Chilton. gn^2, second gnathopod of male; gn^{2*}, palm of same more highly magnified.

The genus was established by Stebbing for the species now under consideration, which had been described under *Hyalella.* Two fresh-water species from Australia described by Sayce belong to *Chiltonia,* and other

species have been described by Geoffrey Smith. Several fresh-water species of *Hyalella* are known from South America, and one that I have examples of (*H. warmingii* Stebbing) presents many resemblances to *Chiltonia*, but has a small palp on the first maxilla and a fringed lobe on the carpus of the second gnathopod in the male. In *Chiltonia mihiwaka* the third uropod is represented by a single small joint, and this character has been incorporated in Stebbing's generic diagnosis. In the Australia species, *C. australis*, the uropod is two-jointed, as in *Hyalella*, so that the characters of the genus require further modification.

From brackish water at Cape Town, South Africa, Barnard has described *Chiltonia capensis*, which has no palp on the first maxilla and has the third uropod single-jointed, but differs in having the two gnathopods alike in both sexes—thus requiring another modification of the characters of the genus.

The presence of very similar species in fresh and brackish waters in New Zealand, Australia, South America, and South Africa is important from a zoogeographical standpoint, and it is desirable that a careful comparison of the species in question should be made.

Genus PARALEPTAMPHOPUS.

This genus was established in 1899 by Stebbing for the subterranean species described under the name *Calliopius subterraneus* and the one found by Mr. G. M. Thomson in a little stream on top of the Old Man Range in Otago and named *Pherusa caeruleus*. In 1893 Della Valle had placed the first species under *Acanthonostoma*, and had stated that the second species was very close to and perhaps identical with the first. I gave some details as to the distribution of the two species in 1909 (1909B, p. 54). Since then I have obtained numerous specimens of each from additional localities, and an examination of them shows that the two species are undoubtedly closely related, and that forms exist that are to a large extent intermediate both as regards structure and mode of life. It will be best to give the facts under each "species" separately.

Paraleptamphopus caeruleus (G. M. Thomson).

Paraleptamphopus caeruleus Chilton, 1909B, p. 54 (with synonyms).

This species is now known to be widely spread over the southern portions of Otago and Southland, It has been recorded from Swampy Hill (near Dunedin), from the Old Man Range, from the neighbourhood of Invercargill, from Ruapuke Island, and I have recently collected it in abundance from several localities at Drummond and Otautau in Southland. In these places it lives in ditches and small streams on the various weeds that grow in the water, in much the same way as the ordinary fresh-water *Paracalliope fluviatilis* does, though this species was not found by me in the same ditches. With *P. caeruleus* there was, however, the other species, *P. subterraneus*, but it was usually found a little deeper down, either on the surface of the mud or actually in the mud. *P. caeruleus* is slightly smaller than *P. subterraneus*, and can readily be distinguished by its dark-blue colour. Most of the specimens are so darkly coloured that they appear black, but some are paler, especially on the appendages.

The differences in structure from some of the forms of *P. subterraneus* are few and unimportant. The one that seems most constant is in the telson,

which is evenly rounded posteriorly and free from setules; its upper surface is slightly convex; the third uropods have the branches not much longer than the peduncle (fig. 2, urp^3) and, when seen in side view, slightly

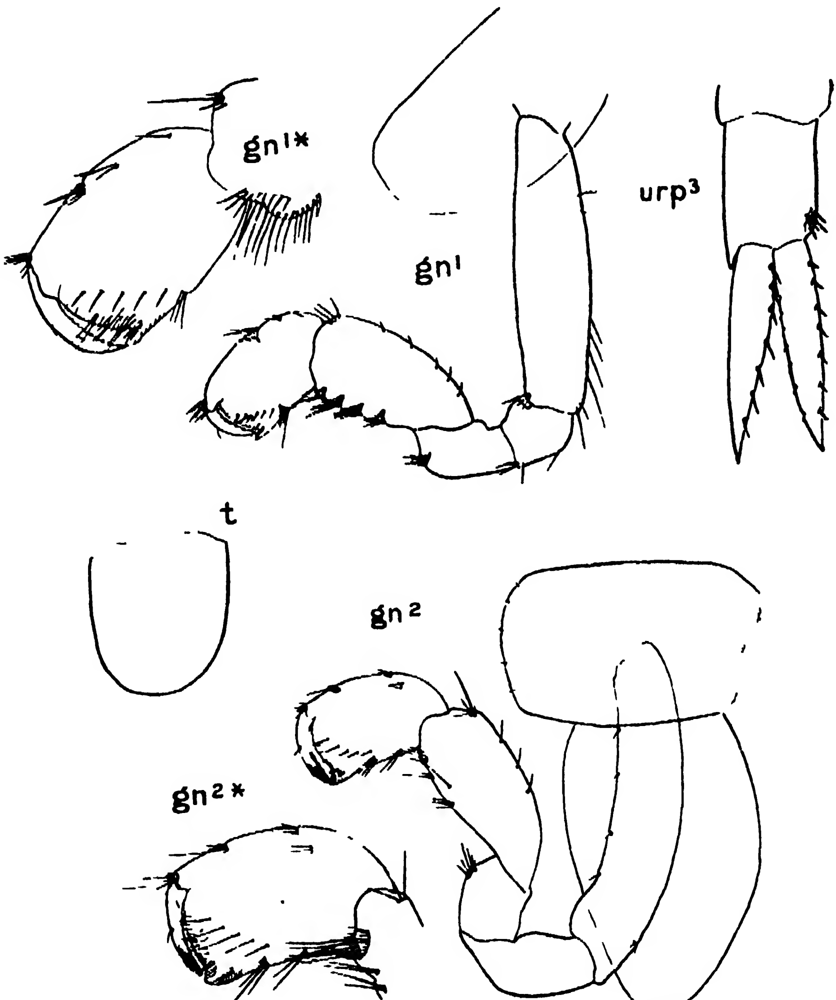

FIG. 2.—*Paraleptamphopus caeruleus* female specimen, from Drummond. gn^1, first gnathopod; gn^{1*}, extremity of same, more highly magnified; gn^2, second gnathopod; gn^{2*}, extremity of same, more highly magnified; urp^3, third uropod; *t*, telson.

curved upwards; the gnathopoda are rather more slender than in *P. subterraneus*, with the armature of the palm somewhat different, the propod bearing crenulate markings at the point where the finger impinges, and the finger having numerous setules towards the extremity (see figs. 2, gn^{1*}, gn^{2*}).

Paraleptamphopus subterraneus (Chilton).

Paraleptamphopus subterraneus Stebbing, 1906, p. 294; Chilton, 1909B, p. 54 (with synonyms).

This species is very widely distributed in New Zealand. It was first obtained in wells at Eyreton not far from the River Waimakariri; it has since been found in wells in Christchurch, Lincoln, Leeston, Ashburton, and Winchester. Later on I collected it in surface streams issuing from river-terraces near the River Porter, a tributary of the Waimakariri, and it is common in streams and ditches near Drummond and Otautau, Southland, where it is found associated with *P. caeruleus*, as already mentioned. Messrs. Lucas and Hodgkin took it in Lake Wakatipu, and in 1908 I found it in a small stream at Duck Cove, Doubtful Sound, in places where the stream was almost covered and shut out from the light by the overhanging rocks and trees. In the North Island it was taken by Lucas and Hodgkin in Lake Taupo at a depth of 700 ft., and in 1911 Mr. W. F. Howlett sent me numerous specimens from a well at Eketahuna. All these specimens are pale and colourless, with eyes imperfect or completely absent, and, though they show considerable differences in the exact shape of the telson, the third uropoda, and the gnathopoda, there is no difficulty in considering them as all belonging to the same species.

In 1914, however, Mr. T. Hall sent me specimens which he had collected at "Clippings," on the range of mountains known as the Remarkables, near Lake Wakatipu, and from Mount Dick, in the same neighbourhood, the animals in the latter case being found at a height of 3,000 ft. above sea-level. These specimens were rather stouter in body than the forms obtained from wells, the third uropods were shorter and similar to those of *P. caeruleus*, and they showed the dark-blue colour characteristic of the latter species, though it was not quite so intense, and some of the specimens were much lighter than others; the telson, too, proved to differ distinctly from that of the type. At first I was inclined to consider them as a new species, but a careful comparison of the forms of *P. subterraneus* from the different localities mentioned has shown that numerous transitional forms exist as regards the individual characters, and that if a new name were given to the forms from "Clippings" and Mount Dick several new names would have to be established for the others. Though largely intermediate between the two species, the "Clippings" and Mount Dick specimens approach more nearly to *P. subterraneus* in the telson, and I therefore look upon them as a variety of that species.

The structure of *P. subterraneus* was somewhat fully dealt with by me in 1894 so far as the underground forms were concerned. It will only be necessary to mention now a few of the points in which differences occur in specimens from other localities. In all specimens the gnathopoda are of similar shape, the first stouter than the second; in the Eyreton specimens the palm of the first is minutely crenulate, but it is even in these from surface waters in Southland. The appearance of the third uropod varies when seen from the side or from above. Fig. 4 shows those of a specimen from Eketahuna, fig. *urp*^{3} being one of the pair seen from above, fig. *urp*^{3*} the other from the side; the branches are not much longer than the base, on the latter there is usually a small tuft of setules at the upper distal angle, and two or three separately placed on each upper margin. In specimens from Southland streams the tuft at the distal

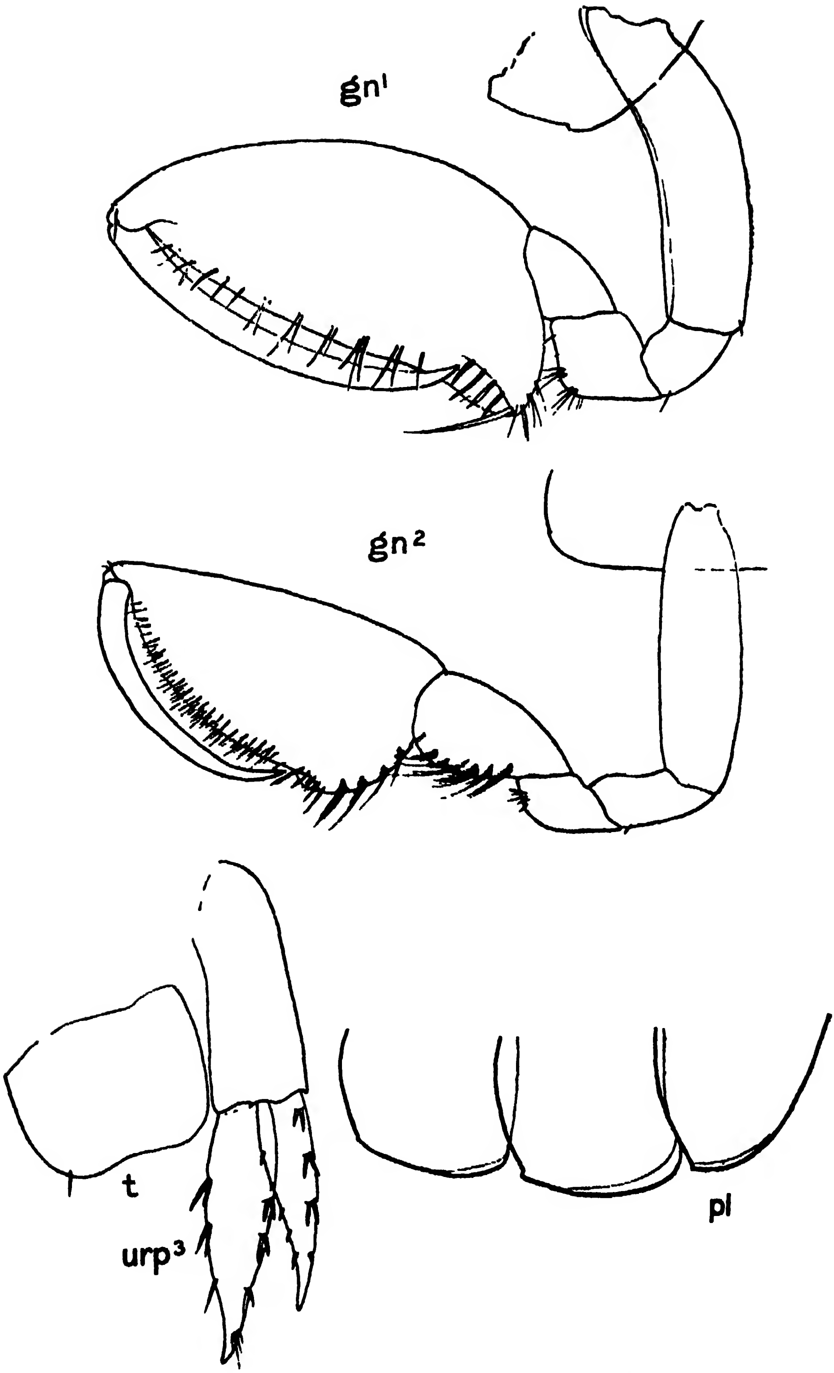

FIG. 3.—*Paraleptamphopus subterraneus:* male specimen from Eyreton (in well), probably immature. *gn*¹, first gnathopod; *gn*², second gnathopod; *pl*, inferior margins of pleon segments 1, 2, 3; *urp*³, third uropod; *t*, telson.

angle may be larger, and there is sometimes a smaller but distinct tuft about the middle of the upper outer margin (see fig. 6). The telson is a flat oblong plate with lateral margins nearly straight, posterior corners narrowly rounded, and each usually bearing a single small setule, the posterior margin slightly concave. All these characters, and especially the last, are subject to modification even in individuals from the same locality; thus one from wells at Ashburton has the posterior margin much more deeply concave, and one corner without a setule (fig. 7).

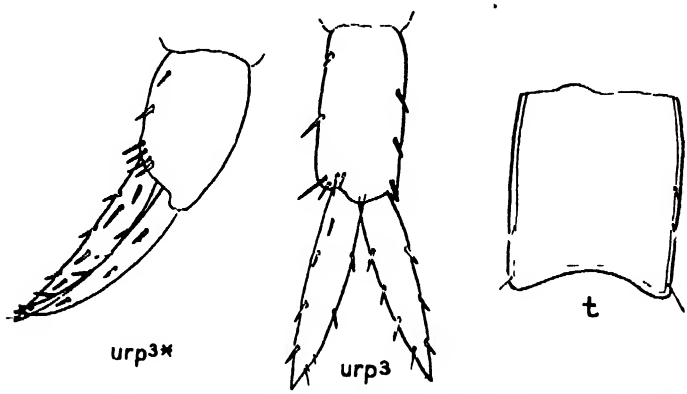

FIG. 4.—*Paraleptamphopus subterraneus:* female specimen from Eketahuna (in wells). *urp*³, third uropod, from above; *urp*³*, the same, side view; *t*, telson.

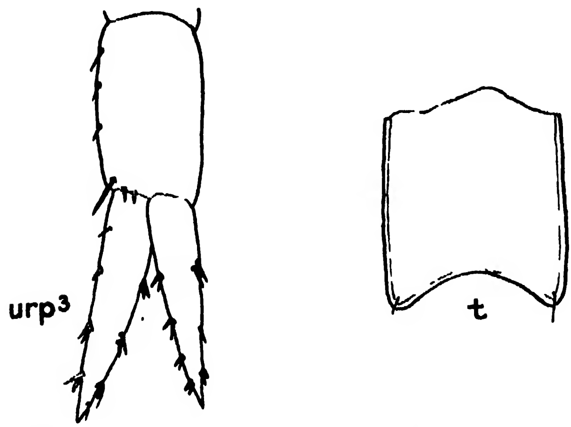

FIG. 5.—*Paraleptamphopus subterraneus:* female specimen, from surface stream, Castle Hill. *urp*³, third uropod; *t*, telson.

In the "Clippings" and Mount Dick specimens the telson differs markedly from the more typical forms. The lateral margins are distinctly convex, the telson itself shorter and broader, the posterior margin deeply concave, and there are three or four setules at each corner and two or three more anteriorly placed on the lateral margin (see figs. 8 and 9).

In 1894 I described from the Eyreton wells a form larger than the usual one, and differing very considerably in having the antennae stouter and plentifully supplied with calceoli, and the gnathopoda very large and

differently formed. The ordinary form is undoubtedly a female, being often found with eggs or young in the brood-pouch, and I looked upon the form with the large peculiar gnathopoda as the male. It differs so much, however, that it is not surprising that Stebbing says (1906, p. 295),

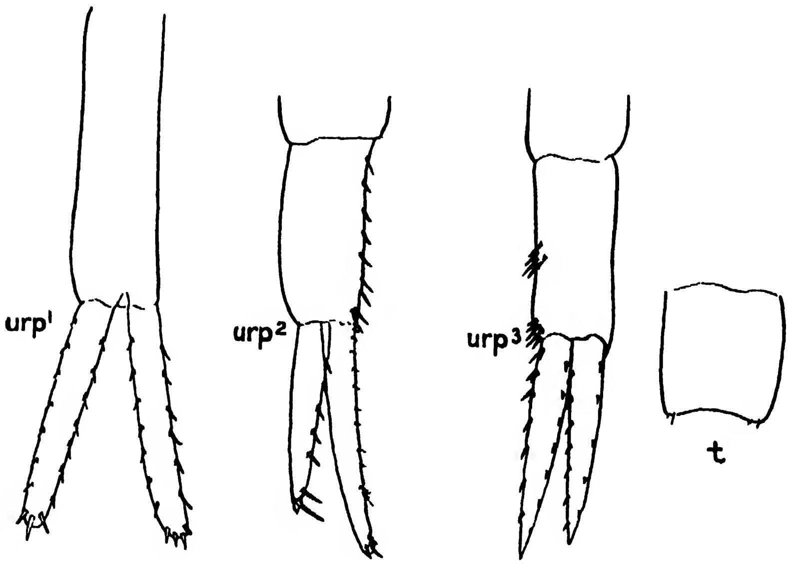

FIG. 6.—*Paraleptamphopus subterraneus*: female specimen, from surface stream, Drummond. *urp*¹, first uropod; *urp*², second uropod; *urp*³, third uropod; *t*, telson.

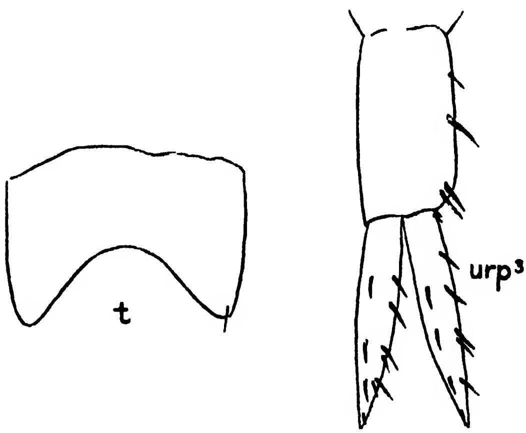

FIG. 7.—*Paraleptamphopus subterraneus*. specimen from a well at Ashburton. *urp*³, third uropod; *t*, telson.

"The supposed male is uncertain in respect to sex and to identity with the species." Unfortunately I have seen very few specimens of the supposed male, and have now records of four only. One was dissected for use in drawing up the description I gave in 1894 and I have now

only its gnathopoda; another specimen was similar in size and structure, and I have all its appendages mounted as micro-slides; a third specimen which appears quite the same is in my collection, undissected; and the fourth, which was rather smaller, I have recently dissected and mounted in the hope that it would perhaps show intermediate characters in the

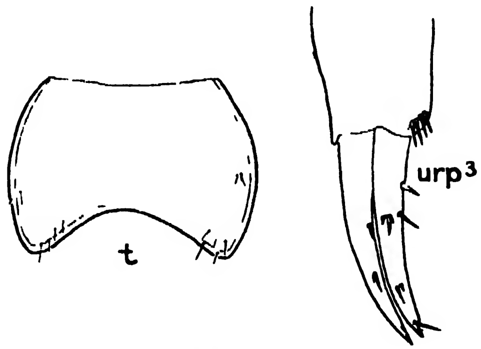

FIG. 8. *Paraleptamphopus subterraneus*: specimen from surface stream, "Clippings," The Remarkables. *urp*³, third uropod, *t*, telson.

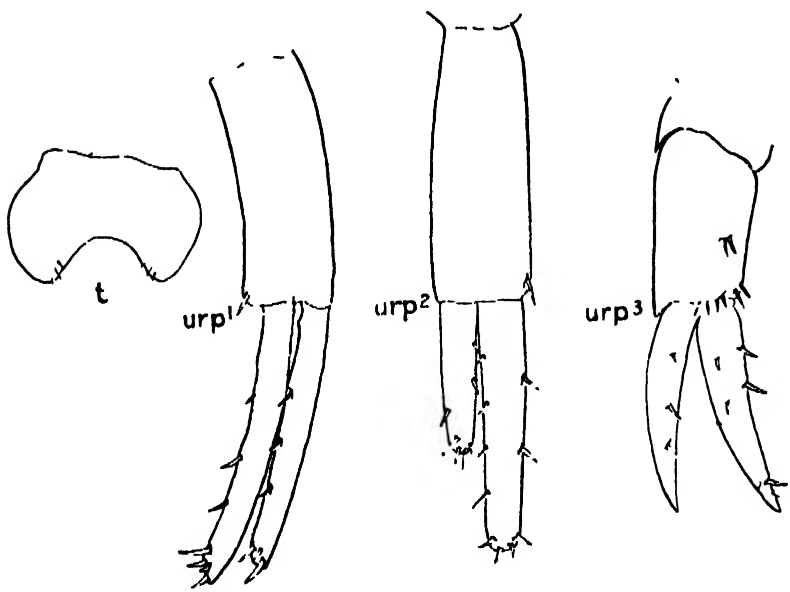

FIG. 9.—*Paraleptamphopus subterraneus*: female specimen from Mount Dick. *urp*¹, first uropod; *urp*², second uropod; *urp*³, third uropod; *t*, telson.

gnathopods between those of the female and the fully developed male. Unfortunately this was not the case, for its gnathopoda, though smaller and less bountifully supplied with spinules (fig. 3, gn^1 and gn^2), are essentially the same as those figured in 1894.

I still feel convinced that the specimens in question are really males of *P. subterraneus*, for they are closely similar in all the characters except

those that may be looked upon as secondary male characters; none of them bears eggs, and it seems unlikely that there should be two species living in the underground waters drawn upon by the one well, that many dozens of specimens of one species, all females, have been obtained, but of the other only less than half a dozen and these all males. It must be mentioned, however, that among the numerous specimens of *P. subterraneus* examined from other localities I have seen no similar males; it is, of course, possible that some may have been overlooked, for the gnathopoda are more or less concealed by the deep side-plates.

I give figures of the telson and uropoda of *P. subterraneus* from different localities. It will be seen that there is considerable variation, just as there is in the subterranean forms of *Niphargus* in Europe, and that in consequence there is room for much difference of opinion as to the number of "species" into which they should be divided. In New Zealand the subterranean species is also found in surface waters, most of these specimens being still colourless and apparently blind; though some—viz., those from "Clippings" and Mount Dick—are found at great heights above sea-level, and in colour and other characters show distinct transitions leading to the true surface form, *P. caeruleus*, from which the subterranean forms may be presumed to have been descended.

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*Material for a Monograph on the Diptera Fauna of New Zealand: Part 2, Family Syrphidae, Supplement A.**

By DAVID MILLER, Government Entomologist.

[*Read before the Wellington Philosophical Society, 24th October, 1922; received by Editor, 31st December, 1922; issued separately, 18th June, 1924.*]

Genus PARAGUS Latreille (1805).

P. myersii n. sp.

♂. Head large and globular, wider than thorax, shining greenish-black with pruinose reflection. Eyes bare, completely holoptic, occupying posterior half of head only, their anterior orbits forming an almost straight line across top; in profile, lower eye-angle well above oral margin; facial orbits almost perpendicular and slightly concave. Face, cheeks, crown of head in front of eyes, and antennae black in ground-colour, but greyish pruinose, except for a black area extending from lower part of facial orbits to anterior oral margin. Sides of face, cheeks, and crown hairy, hairs on sides of face and crown black, erect and dense, so that when seen from above head is tufted in front of eyes; hairs of cheeks grey; a distant groove originating in a distinct depression below eyes runs diagonally to base of antennae. Middle of face bare, not depressed but rather rounded below antennae; a moderate central tubercle, black on centre, below which oral margin slightly projects. Proboscis blackish-brown, palpi paler, linear and swollen at end. Occiput black, depressed, orbits somewhat swollen, greyish-pruinose, wider and clothed below with short pale hair, narrower and clothed with longer hairs above, the hair extending over the rather large ocellar triangle. Top of head comparatively horizontal, antennae situated high up, separated basally, greyish-yellow pruinose, comparatively short, 3rd joint oval, short; arista stout and very short-haired.

Thorax and scutellum shiny blue-black, clothed with long delicate greyish hair. Wings clear, stigma faintly marked; halteres greyish-black. Legs blue-black, femora with long delicate greyish hair; tarsi rather greyish-yellow owing to short closely-set vestiture; posterior protarsi somewhat swollen; anterior tarsi flat, their protarsi broad with anterior inner angle produced, remaining joints broad but shortening and narrowing to onychotarsi.

Abdomen clothed with delicate greyish hair, linear, sides parallel; five visible segments; dull blue-black in colour, a pale opal-white triangular spot at anterior angles of 3rd, 4th, and 5th segments. Genitalia brownish-black.

♀. Eyes broadly dichoptic, their facial orbits convex; vestiture of head shorter than in ♂; a deep sinuated transverse groove across front from eye to eye. Thorax shorter-haired; anterior protarsi not produced at inner angle. Abdomen rectangular, shiny greenish-black; a pair of indistinct spots, seen only in some lights, on 2nd, 3rd, 4th, and 5th segments.

♂. Length, 11 mm. ♀. Length, 10 mm.

Holotype: No. 1261, D. M.

Habitat.—Tararuas, 4,300 ft.; captured by J. G. Myers on flowers of *Ranunculus geranifolius.*

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* Part 2, *Trans. N.Z. Inst.*, vol. 53, pp. 289–333, 1921.

Genus CHEILOSIA Panz. (1809).

C. fulvipes n. sp.

♀. Eyes bare, dichoptic; front brilliant purple, sparsely clothed with black hair, a transverse median depression connected by a distinct longitudinal furrow with apex of ocellar triangle; the latter cupreous and bordered with black; frontal orbits at antennae with a silvery pubescence; lunular area black. Antennae situated well up on head, separated at base, 1st and 2nd joints black; 3rd joint of type and of all other specimens lost. Face shining purple, a patch of silvery tomentum and not excavated beneath antennae; distinct central knob black; sides of face sparsely clothed with short hair; facial orbits narrowly silvery pubescent; oral margin projecting somewhat; cheeks black and clothed with short silvery hair. Proboscis blackish-brown, palpi paler. Occiput purplish-black, depressed, posterior orbits narrowly silvery.

Thorax and scutellum brilliant cupreous, indistinctly clothed with very short hair. Wings somewhat translucent, stigma clouded with tawny; cell Cu_2 very broad owing to veins 1st A and Cu curving into anal angle and cell M respectively; on one wing cross-vein *r-m* is forked, thus meeting vein M_{1+2} in two places; halteres rather tawny. Legs purplish-black, except apices of femora, tibiae, base of all protarsi, and apex of posterior protarsi, which are tawny. Anterior tarsi somewhat broadened; posterior tibiae slightly and middle tibiae distinctly broadened.

Abdomen rather ovate, shiny purplish-black.

♂. Eyes holoptic for a short distance; front black with some erect black hair and a greyish tomentum extending into short white hair below on facial orbits. Antennae black. Face greenish-black, central knob pronounced, black.

Thorax and scutellum rather dull black, with a coppery and purplish tinge and clothed with greyish hair. Legs as in ♀ but tibiae with distinct central dark area; anterior and middle tibiae, particularly the latter, greatly broadened except for very narrow basal portion; posterior tibiae slightly thickened, their protarsi swollen; anterior protarsi and epitarsi broadened somewhat.

Abdomen linear, somewhat shiny, almost black with pair of large glaucous spots one on each side of 2nd, 3rd, and 4th segments. Genitalia brownish.

♀. Length, 6 mm. ♂. Length, 7 mm.

Holotype: ♀, No. 1259, D. M.

Allotype: ♂, No. 1259A, D. M.

Habitat.—Otira (R. J. Harris); Mount Rolleston and Arthur's Pass (J. W. Campbell).

C. captalis n. sp.

♀. Eyes bare, dichoptic; front broad, greenish-black, clothed with delicate white hair; a silvery area of hair, seen in some lights, on each orbit opposite antennae. Antennae situated above middle of head, black with greyish tomentum; 3rd joint oval. Face convex, shiny black, central knob distinct; a silvery patch of tomentum below antennae; a distinct furrow on face from antennae to lower eye-margin. Proboscis and palpi black, Occiput black, depressed, orbits clothed with short silvery hair.

Thorax and scutellum rather shiny greenish or bluish black, clothed with short silvery hair. Wings rather translucent, stigma tawny; halteres

brownish. Legs greenish-black with short greyish vestiture on tibiae and tarsi; posterior protarsi swollen; joints of anterior tarsi broadened and flat.

Abdomen shiny greenish-black, sparsely clothed with short greyish hair; rather ovate, broadest across posterior margin of 2nd segment.

♀. Length, 6 mm.

Holotype: No. 1260, D. M.

Habitat.—Otira (J. R. Harris).

Genus HELOPHILUS Meigan (1822).

H. taruensis n. sp.

♀. Eyes bare; front brownish-black, clothed with delicate blackish-brown hair; a rather broad somewhat tawny band across front. Antennae blackish-brown with a rather greyish tomentum. Face lemon-yellow, a shiny stripe down middle and sparsely clothed with lemon-yellow hair. Oral margin broadly bordered with brownish-black; cheeks greyish-black and clothed with yellow hair. Proboscis and palpi blackish-brown. Occiput rather yellowish, clothed with short yellow hair; the narrow orbits pale greyish-yellow below, but blackish-brown above to vertex.

Thorax blackish-brown, pleurae dull, with a greyish-yellow tomentum, the whole clothed with yellowish to golden hair denser on pleurae and margin of dorsum; the shiny dorsum with a pair of broad greyish-yellow stripes and bordered on each side with this colour. Legs blue-black, sparsely clothed with greyish hair; posterior femora broadened, a tooth-like process present below and some short black spines distally; a tawny spot near apex; onychotarsi tawny; pulvilli and base of claws white, apex of latter black. Wings slightly tinged with brown, veins brown and stigma dark brown; squamae fringed with long branched reddish hair, the alulae with very short hair; cross-vein *r m* slightly beyond middle of cell 1st M_2; halteres tawny.

Abdomen ovate, somewhat shiny blue-black; 1st segment dull grey except for dark spot on each side at posterior margin; large very indistinct paler areas on each side of 2nd, 3rd, and 4th segments; the whole clothed with very short yellowish hair, longer along sides; black rather bristle-like hairs across posterior margin and at angles of 3rd and 4th segments.

♀. Length, 12 mm.

Holotype: No. 1262, D. M.

Habitat.—Tararuas, 2,600 ft. (J. G. Myers).

A specimen of what appears to be the male of this species was found by Mr. J. G. Myers at sea-level, Auckland. Colour and vestiture as in female, though vestiture of abdomen and legs is longer and more golden. Eyes dichoptic, angulated on front; a concave transverse groove at this point, above which orbits are parallel and below divergent. First abdominal segment greyish only on middle; indistinct paler areas on abdomen as in female. Length, 10 mm.

H. hectori n. sp.

♀. Front dull black with greyish tomentum, clothed with blackish hair. Antennae black but with reddish tint and greyish reflection. Face black, the central convexity and a broad area at oral margin widening to orbits clothed with cinereous tomentum; sides of face with a few long and delicate cinereous hairs; facial orbits and cheeks cinereous, the latter haired and

with a black spot at lower eye-margin. Proboscis and palpi blackish-brown. Occiput depressed, greyish-black, clothed with very delicate greyish hair; posterior orbits broad with short grey hairs below, but a single row, becoming double on vertex, of erect black hairs above.

Thorax clothed with greyish to yellow hair with some erect black ones on dorsum; pleurae cinereous to greyish-black. Dorsum velvet-black, a pair of cinereous rather narrow stripes tapering to a point before reaching scutellum; humeri and sides of dorsum cinereous; cinereous area posterior to humeri and extending over alar region. Scutellum clothed with brownish to golden hair, shiny blackish-brown, apex rather tawny. Legs blackish-brown, sparsely clothed with short whitish hairs, which are rather bristle-like and blackish on posterior femora; the latter distinctly thickened, without a distinct inferior tooth-like process but with stout spines and a reddish-yellow spot below distally; lower side of tarsi, particularly protarsi, with a few short stout spines. Wings slightly tinged with brown, stigma tawny; cross-vein *r-m* at middle of cell 1st M_2; squamae fringed with tawny branched hair; halteres tawny.

Abdomen shiny bronze-black, extreme apex tawny; the whole sparsely clothed with short grey hair, longer on sides.

♂. Length, 9 mm.

Holotype: No. 1263, D. M.

Habitat. - Mount Hector, 5,000 ft. (J. G. Myers).

Genus Ocyptamus Macq. (1834).

O. doralis n. sp.

♂. Eyes bare, dichoptic though more approximated at vertex; vertex and upper part of front shiny blackish-brown; anterior margin of this area, which ends a little in front of ocellar triangle, has a median triangular notch of yellow, the apex of which ends just in front of anterior ocellus; remainder of front yellow, the whole sparsely clothed with short blackish to yellowish hair; ocellar triangle bluish-black and elongate. Antennae short, inserted just above middle line of head; yellow except brown outer edge of 3rd joint, which is orbicular; arista dark brown. Face, cheeks, oral margin, and mouth-parts yellow; face descending almost vertically, without tubercle, though rounded at oral margin, which is not projecting.

Pleurae, halteres, and legs yellow; onychotarsi dark-brown and upper side of femora a rather darker yellow. Dorsum shiny bluish-green, margined with yellow, clothed with fine short hair giving a punctured appearance; scutellum bluish-green at base but otherwise brownish. Wings iridescent, clouded at stigma and apex above vein R_{4+5}; vena spuria developed vein-like; halteres yellowish.

Abdomen narrow, linear, 2nd segment slightly constricted; shiny blue-black, sides of 1st segment yellow; a pair of tawny spots on 2nd, 3rd, 4th, and 5th segments, the last pair darker. Genitalia prominent and tawny.

♂. Length, 6 mm.

Holotype: No. 1264, D. M.

Habitat.—Wellington (J. W. Campbell).

Studies of New Zealand Trichoptera, or Caddis-flies: No. 2, Descriptions of New Genera and Species.

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[*Read before the Nelson Institute, 18th October, 1922; received by Editor, 9th November, 1922; issued separately, 18th June, 1921.*]

Plate 10.

IN No. 1 of these studies (*Trans. N.Z. Inst.*, vol. 53, pp. 346–50) I described a new genus and species belonging to the family Sericostomatidae. Succeeding parts were planned to take each of the more important families one by one, revising them thoroughly and adding the new genera and species proper to each. This plan has, however, been modified, as it is important that the new species should be published as soon as possible, while the revisions of the families may be left to later parts. In the present paper the family Rhyacophilidae is fully revised, with a key to all the known New Zealand genera; but there are also described some new genera and species belonging to other families, and the Calamoceratidae are for the first time shown to be represented in New Zealand.

At the present time twenty-seven species and sixteen genera of caddis-flies are known from New Zealand. To these are now added seventeen new species and seven new genera, bringing the New Zealand totals up to forty-four species and twenty-three genera, or considerably more than are known for the whole of Australia. The new genera and species are distributed as follows:—

Family.	Previously described.		Added in this Paper.		Total.	
	Genera.	Species.	Genera.	Species.	Genera.	Species.
Rhyacophilidae ..	2	5	5	7	7	12
Hydroptilidae ..	1	1	1	1	2	2
Hydropsychidae ..	1	4	0	1	1	5
Polycentropidae ..	1	1	0	0	1	1
Calamoceratidae ..	1	1	0	1	1	2
Leptoceridae	4	6	0	1	4	7
Sericostomatidae ..	6	9	1	6	7	15
Total Trichoptera	16	27	7	17	23	44

NOTE.—The genus and species recorded in the first column under the family Calamoceratidae have been previously placed in the Sericostomatidae, but are here removed to their proper family, and constitute the first record of the occurrence of that family in New Zealand.

I wish here to thank all those entomologists in New Zealand through whose help specimens have been received for study or collected in the

field; the individual records are given under each species. I also desire to thank Mr. W. C. Davies, Curator of the Cawthron Institute, for the photograph from which Plate 19 has been prepared.

Family RHYACOPHILIDAE.

Up to the present only two genera of this family have been found in New Zealand—viz., *Hydrobiosis* McL. and *Psilochorema* McL. The former of these is also recorded from Queensland, but the latter is peculiar to New Zealand.* Five new genera are here proposed to be added for the reception of seven new species. The family is a difficult one to study, and in order to facilitate such study I give herewith figures of the wing-venation and a dichotomic key to the seven New Zealand genera:—

KEY TO THE NEW ZEALAND GENERA OF THE FAMILY RHYACOPHILIDAE.

1. Forewing with the branches of M normally developed 2
   Forewing with M_2 and M_3 fused basally for some distance, so that an apparent apical fork is formed distally between them .. .. Genus NEUROCHOREMA n. g., ♂♂.
2. Forewing with the radial cell present, closed distally by a cross-vein; not symmetrically pointed at apex 3
   Forewing with the radial cell absent, and the apex symmetrically pointed Genus TIPHOBIOSIS n. g.
3. Radial cell of forewing not followed distad by a second small closed cell .. 4
   Radial cell of forewing with a second small closed cell attached to it distad, enclosing the wing-spot 7
4. Forewing with both Af_1 and Af_2 sessile on the radial cell 5
   Forewing with either Af_1 or Af_2 or both stalked from the radial cell .. 6
5. Cu_2 in forewing ends at about level of beginning of pterostigma, well beyond 1A; 2A long; fork of Cu_1 not dichotomic, attached basally to Cu_2 by a cross-vein .. .. .. Genus HYDROCHOREMA n. g.
   Cu_2 in forewing ends by a strong curve at same point as 1A, half-way along the wing; 2A very short; fork of Cu_1 dichotomic, very long, not connected with Cu_2 .. .. Genus HYDROBIOSELLA n. g.
6. Forewing with Af_1 sessile on the radial cell, Af_2 stalked Genus HYDROBIOSIS McL.
   Forewing with Af_1 stalked, Af_2 sessile on the radial cell .. .. Genus NEUROCHOREMA n. g., ♀♀.
7. The small cell distad from the radial cell in forewing is closed distally by fusion of R_1 and R_5; veins of the distal part of the forewing neither close together nor parallel .. .. Genus SYNCHOREMA n. g.
   The small cell distad from radial cell in forewing is closed distally by a cross-vein; veins of the distal part of the forewing close together and parallel .. .. Genus PSILOCHOREMA McL.

Genus HYDROBIOSIS McL. (Text-fig. 1.)

McLachlan, *Journ. Linn. Soc. London*, 1871, x, p. 206.

This genus can at once be recognized by the large pterostigma, with R_1 and sometimes even R_2 running through it; the presence of a closed radial cell in the forewing only, with Af_1 sessile upon it but Af_2 well stalked; the absence of the median cell in both wings; the long Af_2 in the hind-wing, with short stalk, and the very long 2A in the forewing. Text-fig. 1 shows these characters clearly.

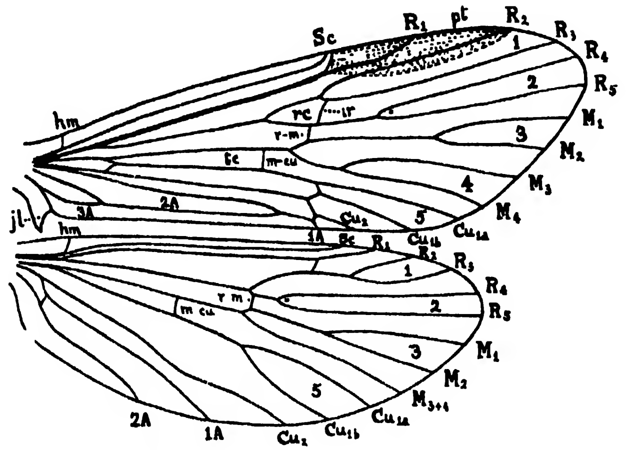
A peculiar character of the genus, not previously noticed, is that the labial palpi appear to be four-segmented, owing to the mentum being very

* *Ps. (?) aculeatum* Blanchard is a Chilian insect doubtfully referred to this genus.

strongly bifid. The same character is to be found in *Tiphobiosis* n. g., and is possibly present in other related genera also.

Genotype.—*Hydrobiosis frater* McL. (New Zealand.)

Four species of this genus are known – viz., *H. frater* McL., *H. umbripennis* McL., *H. ingenua* Hare, and *H. stigma* Ulmer; the first three of these occur in New Zealand only, the fourth in Queensland. The description of *H. ingenua* given by Hare mentions neither the venation nor the form of the male appendages, so that the species is quite unrecognizable



TEXT-FIG. 1.—*Hydrobiosis umbripennis* McL., ♂. Wing-venation. (For lettering see p. 314.)

except by examination of the type. I have seen specimens in Mr. G. V. Hudson's collection determined by Mr. Hare as *Hydrobiosis occulta* Hare (a species which he described at the same time as *H. ingenua*), and they undoubtedly belong to the genus *Hydropsyche;* so I omit the species *occulta* Hare from the list of known species of *Hydrobiosis*, and remove it to *Hydropsyche*. Whether *H. ingenua* Hare really belongs to *Hydrobiosis* or not I am unable to say.

Genus PSILOCHOREMA McL. (Text-fig. 2.)

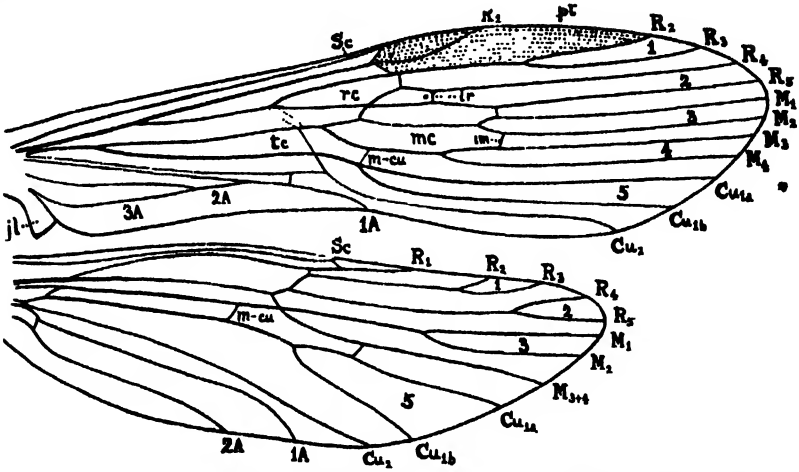
McLachlan, *Trans. Entom. Soc. London*, 1866, ser. 3, v, p. 273.

A very remarkable genus, recognizable at once by the closely parallel arrangement of the veins in the distal part of the forewing; by the peculiar shape of the forewing, which has the costal and posterior margins parallel for the basal half, but the apical half of the wing is dilated by the outward curving of the posterior margin from the end of 1A to the apex; by the very elongated pterostigma of the forewing, and by the presence of an extra small closed cell placed distally from the radial cell in the forewing, between R_4 and R_5, and closed distally by a short cross-vein. These characters are clearly shown in text-fig. 2.

It should be noted that McLachlan, in his diagnosis of this genus, states that five apical forks are present in both the forewing and the hindwing. This is an error, Af_4 being absent in the hindwing, as is all known Trichoptera.

Genotype.—Psilochorema mimicum McL.

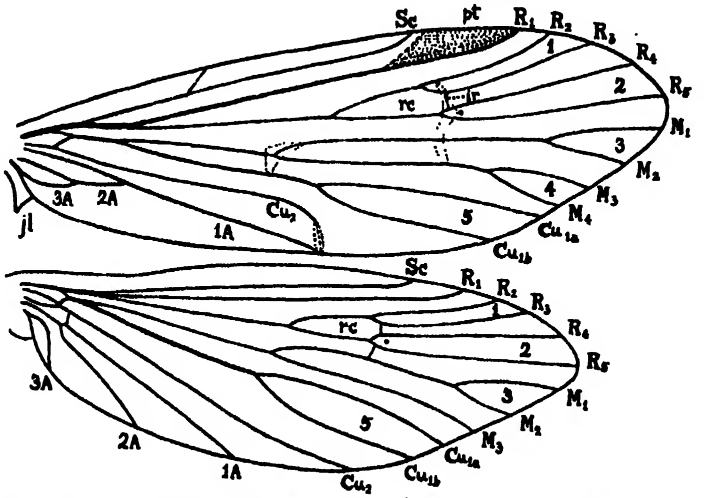
Only two species are known, *Ps. mimicum* McL. and *Ps. confusum* McL., both confined to New Zealand.



Text-fig. 2.—*Psilochorema confusum* McL., ♀. Wing-venation. (For lettering see p. 314.) A small hyaline area is enclosed by the dotted lines in forewing.

Genus Hydrobiosella n. g. (Text-fig. 3.)

Allied to *Hydrobiosis* McL., but easily distinguished from it by the following characters: A closed radial cell present in both wings, with Af_1 and Af_2 sessile upon it. In the forewing, the humeral veinlet is replaced



Text-fig. 3.—*Hydrobiosella stenocerca* n. g. and sp., ♂. Wing-venation. (For lettering see p. 314.) The dotted lines in forewing indicate the positions of small hyaline areas.

by an oblique veinlet situated nearly half-way along Sc. Median cell absent in both wings; Af_3 and Af_4 in forewing, and Af_3 in hindwing, all short forks with very long stalks. The cubital fork, Af_5, long and strongly

formed in both wings, and of normal dichotomic shape in forewing and not connected with Cu_2 by a cross-vein. Anal veins in forewing looped up into the typical short double Y-vein found in so many Trichoptera, 2A not being lengthened as in *Hydrobiosis*. Pterostigma short in both wings. Tibial spurs 2, 4, 4, as also in all the New Zealand genera of this family.

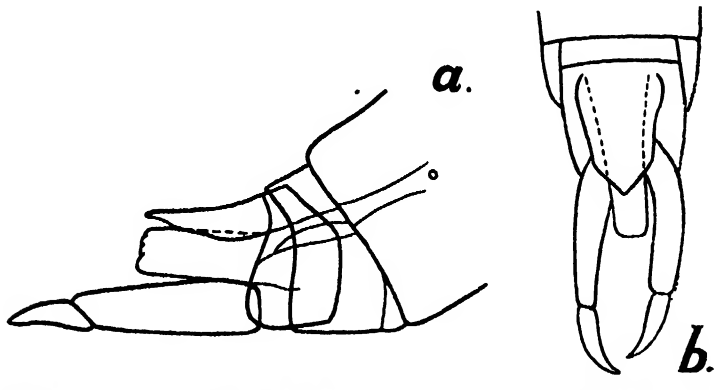
Genotype.—*Hydrobiosella stenocerca* n. sp. (New Zealand.)

Hydrobiosella stenocerca n. sp. (Plate 19, figs. 1, 2, and text-figs. 3, 4.)

Total length, 4–5·5 mm.; forewing, 7–9 mm.; expanse, 15–19 mm.

Head.—Eyes greyish-black. Vertex with a strong tuft of yellowish hairs extending between bases of antennae. Antennae somewhat shorter than forewing, yellowish-brown, strongly annulated with dark brown; the basal segment with a tuft of dark hairs above it. Maxillary palpi brownish, with the bases of segment 3–4 yellowish-brown. Labial palpi long and very slender, dull-brownish.

Thorax fuscous, marked with brown; pronotum with stiff, dark hairs, and sometimes also with some yellowish hairs like those on the vertex. Legs testaceous, the tarsi slightly darkened basally.



TEXT-FIG. 4.—*Hydrobiosella stenocerca* n. g. and sp., ♂. Appendages (× 40). *a*, lateral view; *b*, dorsal view. Note the long, narrow, two-segmented gonapophyses. (10 per cent. KOH preparation.)

Wings.—Forewing irregularly mottled with medium fuscous and yellowish-brown, showing several more or less conspicuous blotches of the darker colour, notably one across Cu_1 somewhat before middle of wing, and a larger oblique and somewhat curved one arising about middle of posterior margin and running upwards and outwards over base of cubital fork on to M_{3+4}. Costal and apical margins always more or less spotted with alternate fuscous and yellowish-brown patches, and pterostigma irregularly marked with both these colours. All the markings very variable; some specimens, usually those of larger size, being very boldly and beautifully marked, while others, usually of smaller size, have the markings more or less obliterated, and appear much less variegated in colour. Hindwing semi-hyaline, pale fuscous, slightly darker distally than basally, somewhat iridescent along main veins, and sometimes with slight mottling like that of forewing around apical margin.

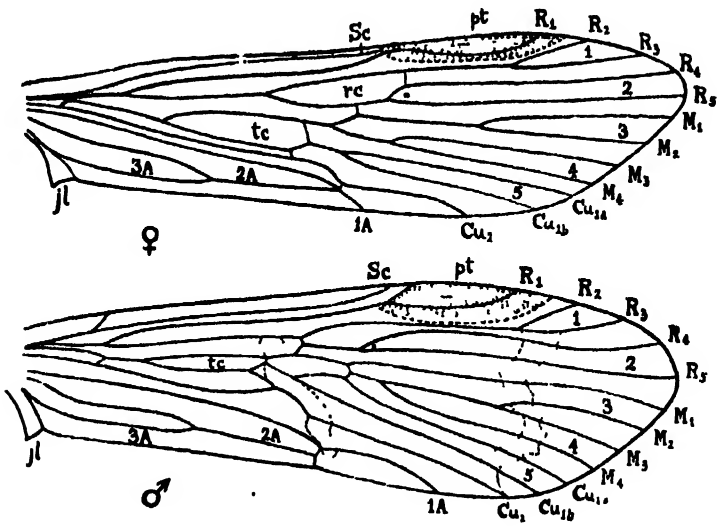
Abdomen dark fuscous, including appendages of male, of which a preparation in 10 per cent. KOH solution is shown in text-fig. 4; they are remarkable for their elongate, narrow form. In the dried insect the two gonapophyses often appear closely contiguous, almost as if fused together in the middle line In the female the last segments of the abdomen are drawn out into a slender ovipositor about 2 mm. long, carrying at its extremity two minute ear-like appendages.

Types. Holotype male (expanse 17·5 mm.) from Gouland Downs (7th February, 1922, R. J. T.); allotype female (expanse 15·5 mm.) from Nelson (29th December, 1920, A. Philpott); and series of males from Nelson, Dun Mountain, Mount Arthur, and Gouland Downs: all in Cawthron Institute collection. The holotype male is selected for the boldness of its markings, and is shown in Plate 19, fig. 1.

Habitat.—Fast-running streams throughout the Nelson district as far as Collingwood and Gouland Downs; also around Wellington, though apparently not so common, and occasionally in Canterbury. This species is readily attracted to light, and is a very rapid runner, dashing about wildly when captured.

Genus NEUROCHOREMA n. g. (Text-figs. 5, 6.)

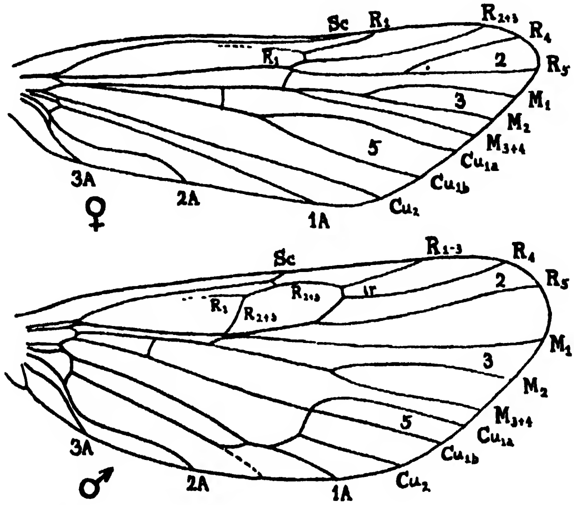
A very distinct genus, differing from all the other New Zealand representatives of the family by the great dissimilarity in the venation of the wings in the two sexes, and also by the absence of the first apical fork, and



TEXT-FIG. 5.—*Neurochorema decussatum* n. g. and sp. Venation of forewing of female (above) and male (below). (For lettering see p. 314.) Note the fusion of M_2 and M_3 basally in the male. In the male the dotted lines indicate enclosed hyaline areas.

the incompleteness of R_1 basally, in the hindwing. Wings considerably broader in male than in female: in the latter, Sc, at about half-way in both wings, approaches very close to the costal border, and runs in contact with it from there on to its termination. Pterostigma of forewing very

large, with R_1 running through it. In both sexes, forewing has all five apical forks present, but hindwing has only Af_2, Af_3, and Af_5. The correct naming of the veins in the male is only possible by comparison with those of the female, when it will at once be seen that, in the forewing, M_2 and M_3 have partially coalesced in the male, so as to produce an *apparent* fork between them distally, whereas the true apical forks, Af_3 and Af_4, lie one above and one below this apparent fork respectively. The branches of the cubitus and the end of 1A are also abnormally developed in the male, and 1A takes much the same position distally that Cu_2 does in the female, as can be seen from text-fig. 5. In the hindwing the male shows very high



TEXT-FIG. 6.—*Neurochorema decussatum* n. g. and sp. Venation of hindwing of female (above) and male (below). (For lettering see p. 314.) Note the closed cell in the radial area of the male, with the incomplete stem of R_1 attached to it above, also the basal fusion of M_2 with M_{3+4}, and the peculiar structure of the cubitus and 1A.

specializations, a wide closed cell being formed below the distal end of Sc; this cell is bounded by R_{2+3} basally, R_{1-3} above, R_{4+5} below, and by a cross-vein distally. M_2 has become fused basally with M_{3+4} in the same manner as with M_3 in forewing. Cu_2 has become bent and fused for a short distance with 1A, which is also bent, and there is a strong cross-vein connecting Cu_2 with the fork of Cu_1. Text-fig. 6 shows how much more highly specialized the hindwing of the male has become in comparison with that of the female. Tibial spurs, 2, 4, 4. Abdomen of female not produced into an elongated ovipositor.

Genotype.—Neurochorema decussatum n. sp. (New Zealand.)

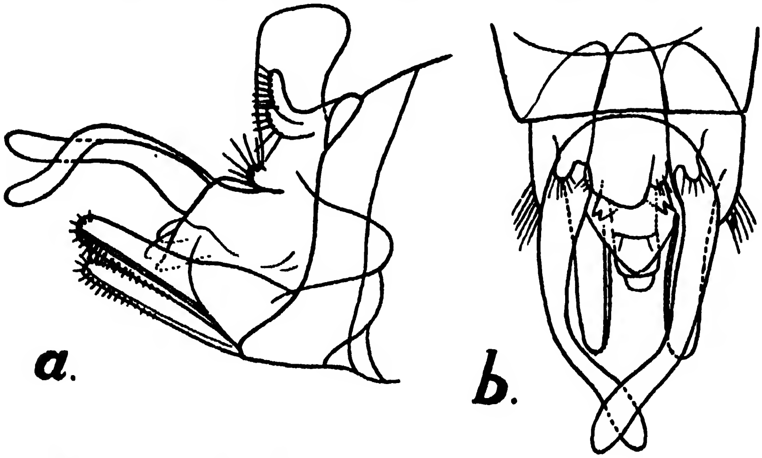
Neurochorema decussatum n. sp. (Plate 19, figs. 3, 4; text-figs. 5–7.)

Total length, ♂ 5 mm., ♀ 5·5 mm.; forewing, ♂ 8 mm., ♀ 8·5 mm.; expanse, ♂ 17 mm., ♀ 18 mm.

Head dark brown, with pale hairs; eyes brown; antennae brown, the basal segment swollen; palpi fuscous.

Thorax very dark brown, with pale hairs on prothorax. Legs pale testaceous.

Wings. Forewing semitransparent yellowish-brown, with darker brown pterostigma; male with a clearly marked whitish band crossing wing obliquely from about middle of R_1 outwards and downwards to point of junction of 1A and 2A, and most strongly visible in cubital region, where veins are bent to run alongside it, and with a less clearly marked pale zigzag fascia descending from distal end of pterostigma across wing to end of Cu_2; these markings are present in female also, but much less conspicuously. In male, the costa carries a series of black hairs, especially noticeable towards pterostigma, but these are absent in female. In both sexes there is a strongly marked patch of dark hairs at junction of 3A with 2A. Numerous short upright hairs are present on wing, those in distal half being very pale, those on basal half being pale also in female,



TEXT-FIG. 7.—*Neurochorema decussatum* n. g. and sp., ♂. Appendages (× 50). *a*, lateral view; *b*, dorsal view. Note the crossed pre-anals. (10 per cent. KOH preparation.)

but pale mixed with dark hairs in male, especially along Cu and its branches, where there are numerous dark hairs. Hindwing hyaline, iridescent, with pale yellowish-brown hairs distally, and pale fringe of same colour.

Types.—Holotype male (Nelson, 5th October, 1920, A. Philpott), allotype female (20th October, 1920, A. Philpott), and series of five paratype males, taken October to November, 1920, by Mr. Philpott, at Nelson: all in Cawthron Institute collection.

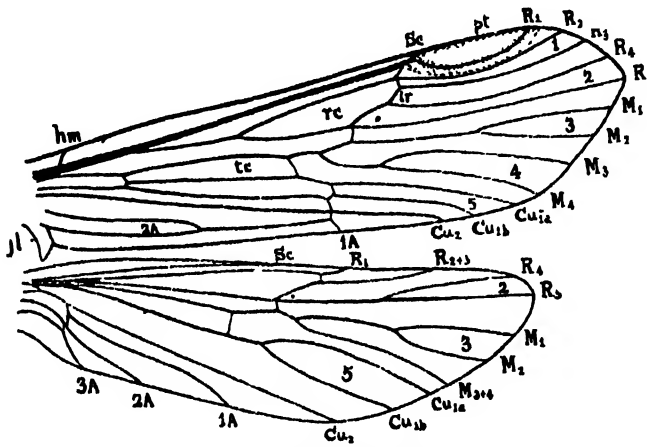
Habitat.—South Island of New Zealand, especially around Nelson. Other localities are Cass, Canterbury, and also around Invercargill. Probably widely distributed.

Abdomen blackish; appendages of male yellowish-brown, pre-anals crossed as shown in text-fig. 7; in the dried insect they sometimes appear evenly more strongly crossed.

Genus HYDROCHOREMA n. g. (Text-fig. 8.)

Allied to both *Hydrobiosis* and *Hydrobiosella*, but differing from both of them in the absence of Af_1 in the hindwing, R_{2+3} being a simple vein without a terminal fork. It resembles *Hydrobiosella* in having both Af_1 and Af_2 of forewing sessile upon the closed radial cell, whereas *Hydro-*

biosis has Af_1 sessile but Af_2 stalked. It also resemble *Hydrobiosis* in the form of the two median forks, Af_4 being a very long fork with short stalk, Af_3 a somwhat shorter fork with stalk about as long as the fork itself; in *Hydrobiosella* these two forks are both short terminal forks with very long stalks. The structure of the cubitus in the forewing is very similar to that in *Hydrobiosis* i.e., considerably more specialized than in *Hydrobiosella*, where the large fork of Cu_1 is free and of primitive dichotomic form. Anal area of forewing with both 2A and 3A well developed, the former joining 1A at the bend of Cu_2 just below point where Cu_1 forks, and the latter extending a little beyond half-way from base to this point. Pterostigma of forewing well developed, with R_1 running through it as a loop. Sc running alongside or fused with R_1 in forewing, separate from it in hindwing, but very short, ending up before half-way along costa. Hindwing with Af_2 apparently forked, but position of wing-spot, placed apparently in angle between R_{2+3} and R_{4+5} at their origins, would



TEXT-FIG. 8. *Hydrochorema crassicaudatum* n. g. and sp., ♂. Wing-venation. (For lettering see p. 314.)

appear to indicate that there has been a suppression of the extra cell to be described in next genus; in this case the genus *Hydrochorema* would show a more highly evolved state of the radial sector in hindwing than does *Synchorema*, though the same region remains more primitive in forewing. General shape of wings rather long and slender, the forewing gradually widening from base outwards to end of pterostigma, and then narrowing quickly to form a bluntly-pointed apex on R_5. Hindwing with apex at R_5, but practically in line with costa. Tibial spurs, 2, 4, 4. Male with long, forcipate gonapophyses.

Genotype.—Hydrochorema crassicaudatum n. sp. (New Zealand.)

Hydrochorema crassicaudatum n. sp. (Plate 19, fig. 5; text-figs. 8, 9 *b*. 10 *a*.)

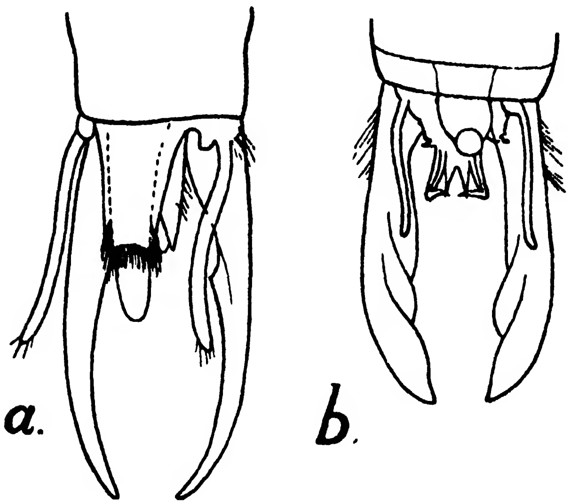
♂. Total length, 4 mm.; forewing, 6·7 mm; expanse, 14 mm.

Head brown, very hairy: eyes dark brown; antennae nearly as long as forewing, medium brown, with tuft of dark hairs below bases; colour of antennae darkening towards tip, and all segments very lightly annulated with darker brown; maxillary and labial palpi dull-brownish.

Thorax very dark brown. Legs femora medium testaceous; fore and hind tibiae dark brown, middle tibiae somewhat paler, very hairy; spurs testaceous; tarsi rather dark brown annulated with paler brown.

Wings.—Forewing a medium fuscous, covered with numerous raised hairs, some dark, some yellowish-brown; a strong fringe of blackish hairs along termen, longest at tornus; pterostigma 1·2 mm. long, strongly marked. dark fuscous; termen with row of pale golden-brown spots just indicated along margin, and similar row parallel to it from end of pterostigma to behind tornus; veins brown. Hindwing subhyaline, with brownish veins; membrane slightly infuscated apically; fringe of delicate brownish hairs.

Abdomen blackish, tenth tergite and pre-anal appendages dark, gonapophyses and penis semitransparent yellowish-brown. Sternites 8 and 9, with conspicuously projecting mid-ventral spines. Text-figs. 9 *b*, 10 *a*, show a preparation of the appendages in 10 per cent. KOH solution, seen from



TEXT-FIG. 9. Dorsal views of male genital appendages in the genus *Hydrochorema* n. g. *a*, in *H. tenuicaudatum* n. sp.; *b*, in *H. crassicaudatum* n. sp. The large forceps in each case is formed by the two gonapophyses. (× 40.) (10 per cent. KOH preparation.)

above and laterally. In the dried specimen the very long, thickened forceps formed by the gonapophyses is the distinguishing mark of this species, and has suggested the specific name.

♀. Unknown.

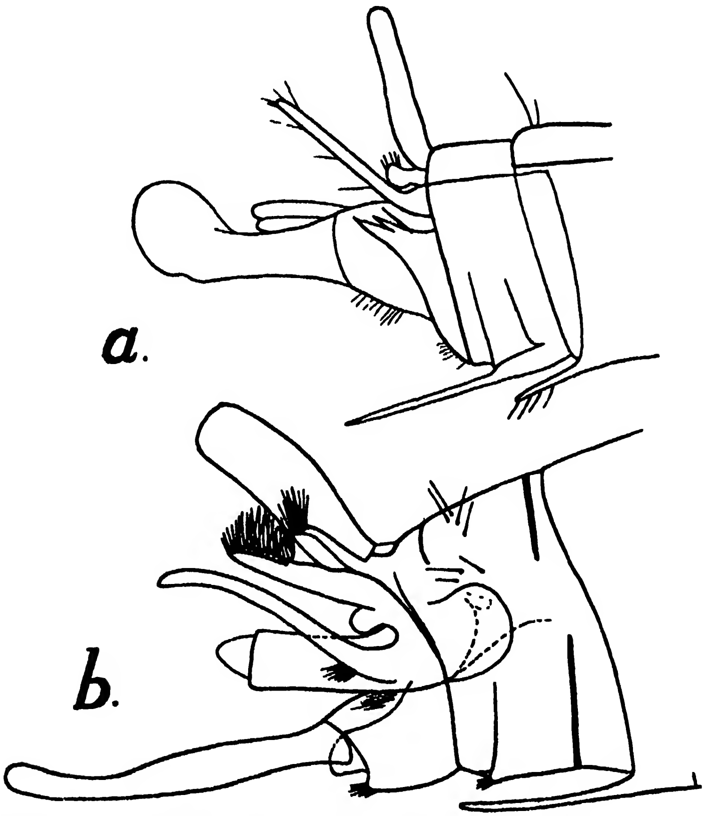
Types.—Holotype male. Nelson (15th December, 1921, A. Philpott); two other males, of larger size and more brownish coloration, expanding about 19–20 mm., one from Takaka (6th February, 1921, R. J. T.), and one from Rotorua, North Island (18th November, 1919, R. J. T.); this last specimen is rather rubbed and old, and has been used for the preparation of the appendages drawn in text-figs. 9 *b*, 10 *a*. All the above in Cawthron Institute collection.

Hydrochorema tenuicaudatum n. sp. (Plate 19, fig. 6; text-figs. 9 *a*, 10 *b*.)

♀. Total length, 6 mm.; forewing, 10·5 mm.; expanse, 22 mm.

Head, thorax, and *abdomen* blackish-brown; eyes dull-blackish; antennae about as long as forewing, brown, annulated with darker brown on every segment. Legs entirely pale testaceous.

Wings.—Forewing blackish-fuscous, with few very short upstanding yellowish-brown hairs; pterostigma not very distinct; termen with very distinct row of golden-brown spots and very short fringe of brownish hairs; a suggestion of parallel row of spots from end of stigma down to behind tornus, but due only to small groups of golden-brown hairs. Hindwing subhyaline, iridescent, with dark-brown veins and short fringe of brown hairs.



TEXT-FIG. 10.—Lateral views of male genital appendages in the genus *Hydrochorema* n. g. *a*, in *H. crassicaudatum* n. sp.; *b*, in *H. tenuicaudatum* n. sp. Note the upturned process of the tenth tergite above, the slender pre-anals, and the long gonapophyses. (10 per cent. KOH preparation.) (× 40.)

♂. Differs from female in being of somewhat smaller size and with somewhat narrower wings, the forewings very dark, almost black. Appendages as shown in text-figs. 9 *a*, 10 *b*; gonapophyses forming an elongated slender forceps, which is diagnostic of the species in the dried specimen. Only sternite 8 with a projecting spine.

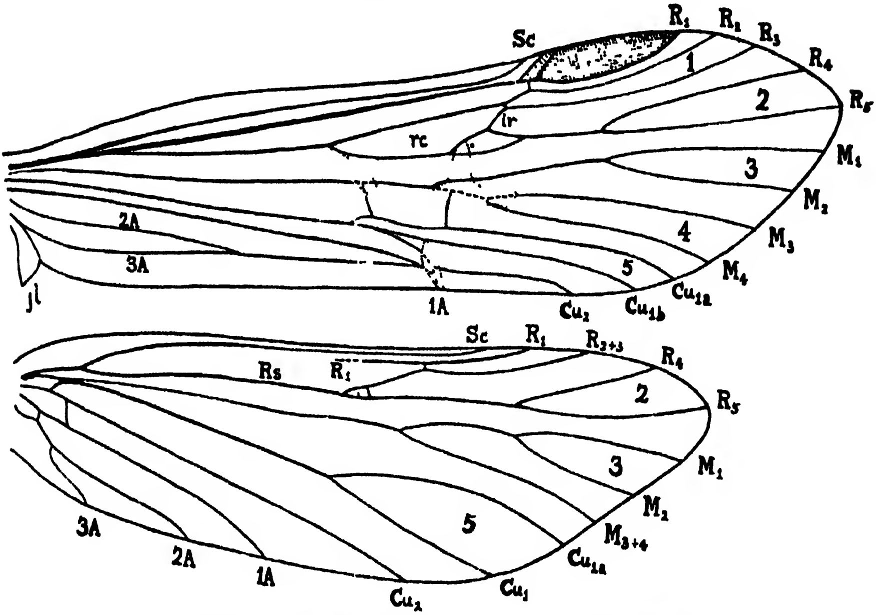
Types.—Holotype female and allotype male, Mount Arthur, 4,000 ft. (28th February, 1921), taken by Mr. A. Philpott; both in Cawthron Institute collection. Both specimens were in perfect condition, but the male has since been badly damaged by an accident, so the female has been made the holotype. The appendages of male have been cut off and treated with 10 per cent KOH for preparation of text-figs. 9 *a*, 10 *b*.

Habitat.—Mount Arthur, Nelson Province, is the only locality for this insect, so far as known.

A female taken by myself on Ben Lomond, Queenstown (15th December, 1921), may possibly belong to this species, but is considerably smaller than the holotype, and with narrower wings.

Genus SYNCHOREMA n. g. (Text-fig. 11.)

Closely allied to *Hydrochorema* n. g., with which it agrees in the important characters of the general shape of wings, the absence of Af_1 in hindwing, and the general form of median and cubital apical forks, but differing



TEXT-FIG. 11.—*Synchorema zygoneura* n. g. and sp., ♂. Wing-venation. (For lettering see p. 314.) Note the formation of the extra small cell enclosing the wing-spot, owing to a partial fusion of R_4 and R_5. The dotted lines in forewing indicate the positions of small hyaline areas.

from it in the following important points: Hindwing with main stem of R_1 atrophied, but with Sc well developed, and running close to costa for three-fourths of its length. In both wings Af_2 appears to be stalked; but there is a small cell present, attached distally to radial cell in forewing, and occupying angle between R_{2+3} and R_{4+5} at their origins in hindwing, and inside this cell can be seen the wing-spot. This shows clearly that in both wings R_4 and R_5 have become secondarily fused together for a considerable distance, thus shortening the fork Af_2 and making it appear stalked, but leaving the wing-spot, which always occurs

in angle between R_4 and R_5, in secondary cell formed by this fusion This formation is unique, so far as I know, in the order, but may profitably be compared with that found in forewing of *Psilochorema* (text-fig. 2), where a secondary cell has been formed by development of an extra cross-vein, so as to enclose within it the wing-spot as shown. In this latter case it will be noted that no fusion of R_4 with R_5 has taken place. Tibial spurs 2, 4, 4. Appendages of male very short.

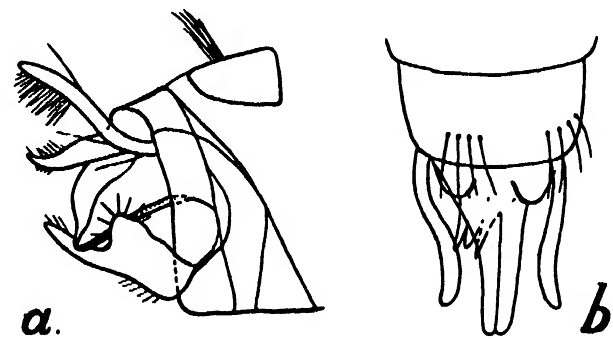
Genotype.—Synchorema zygoneura n. sp. (New Zealand.)

Synchorema zygoneura n. sp. (Plate 19, fig. 7; text-figs. 11, 12.)

♂. Total length, 4 mm.: forewing, 6·7 mm.; expanse, 14 mm.

Head, *thorax*, and *abdomen* brownish; eyes black; antennae and legs pale testaceous.

Wings.—Forewing semitransparent subfulvous, with numerous short upright golden-grown hairs; pterostigma darker, brownish; venation brownish; fringe of pale-brownish hairs of moderate length. Hindwing hyaline, iridescent, with a fringe of short dark-brown hairs very closely set above apex of wing, but with longer and paler hairs, less closely set, around termen and posterior margin; venation brown.



TEXT-FIG. 12.- *Synchorema zygoneura* n. g. and sp., ♂. Appendages (× 55). *a*, lateral view; *b*, dorsal view. (10 per cent. KOH preparation.)

Appendages very short, as shown in text-fig. 12; in the dried specimens they are sometimes scarcely to be discerned, except for the two slender and slightly clubbed pre-anal appendages.

Female closely resembling male, but larger (expanse, 16·5 mm.), and usually with forewings somewhat brighter in colour.

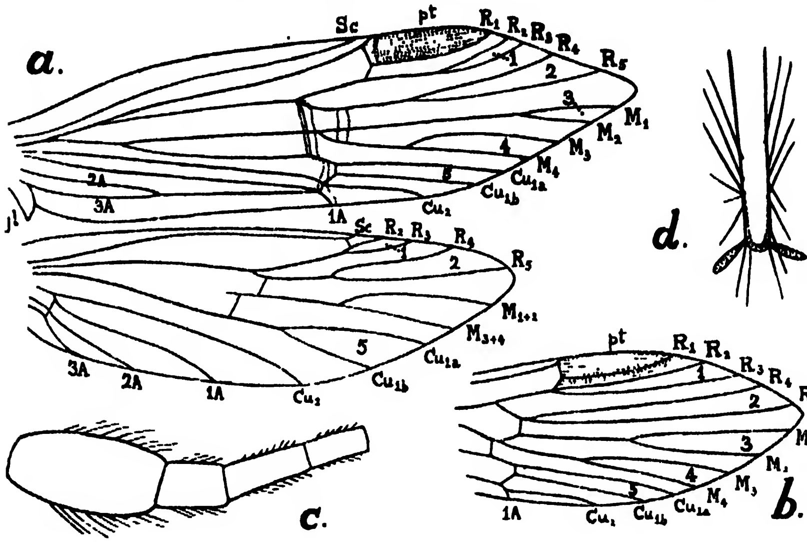
Types.—Holotype male, Mount Arthur, 4,500 ft. (23rd December, 1921, A. Philpott). Allotype female, Arthur's Pass, 2,800 ft. (19th January, 1920, R. J. T.). Also other males from Nelson (6th January, 1921, A. Philpott), Gouland Downs (7th February, 1922, R. J. T.), and females from Arthur's Pass (19th January, 1920, R. J. T.) and Queenstown (14th December, 1919, R. J. T.): all in Cawthron Institute collection. The Nelson specimen has been used for the 10 per cent. KOH preparation from which text-fig. 12 has been drawn. The Gouland Downs male and Queenstown female are slightly less subfulvous than the others, showing a distinct tinge of greyish.

Habitat.—South Island of New Zealand; rare.

This species closely resembles *Hydrochorema crassicaudatum* n. sp. in size and shape, but can be distinguished from it by its more fulvous forewings, its peculiar venation, and the very short anal appendages of the male.

Genus Tiphobiosis n. g. (Text-fig. 13.)

Wings narrow, forewing with posterior margin parallel to costa, apex symmetrically pointed and lying between R_5 and M_1; hindwing also pointed, apex just below R_5. Forewing with all five apical forks present: hindwing with only 1, 2, and 5. Pterostigma strongly developed in forewing. No closed cells present in either wing, except only thyridial cell of forewing. Sc well developed in both wings, R_1 and basal part of M obsolescent in hindwing. Forewing with fork of Cu_1 of specialized form, very narrow; 2A meets 1A close to its end, and 3A meets 2A about half-way along its length. Tibial spurs 2, 4, 4, those of fore tibiae greatly



Text-fig. 13. Details of structure in the genus *Tiphobiosis* n. g. *a*, wing-venation of *Tiphobiosis montana* n. sp., ♀. *b*, distal half of forewing of *T. fulva* n. sp., ♀. *c*, first four segments of antenna of *T. montana* n. sp., ♂ (× 75). *d*, end of elongated ovipositor of female of *T. montana* n. sp., showing the two small, ear-like gonapophyses (× 75). In *a* the dotted lines in forewing indicate the position of the small hyaline areas. (For lettering of *a* and *b* see p. 314.)

reduced. Male with short gonapophyses but long pre-anal appendages and outgrowth of tenth tergite. Female with end segments of abdomen very long and narrow, forming an elongated ovipositor with the two minute ear-like gonapophyses at its extremity (text-fig. 13 *d*).

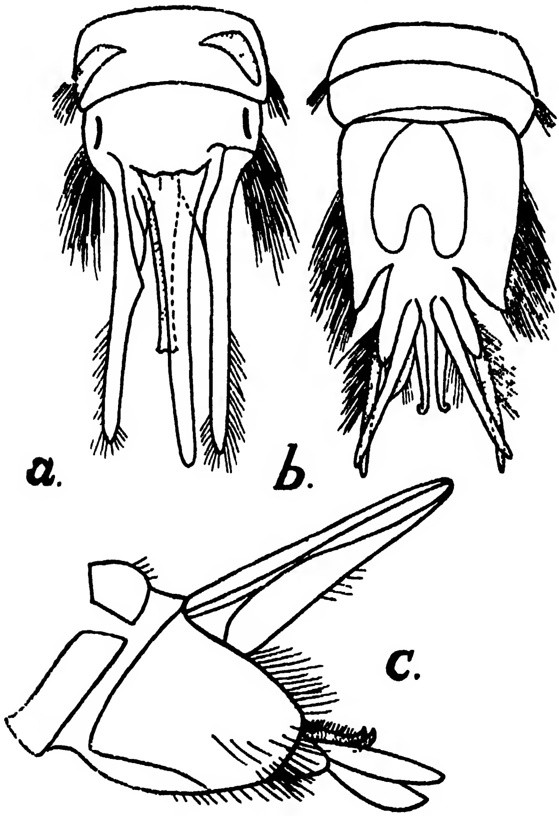
Genotype. Tiphobiosis montana n. sp. (New Zealand.)

This peculiar genus is very distinct, but is probably related fairly closely to *Hydrochorema*, from which it differs in the shape of wings, absence of radial cell in forewing, presence of Af_1 and absence of Af_3 in hindwing, obsolescence of R_1 and basal portion of M in same wing, reduction of spurs in fore tibiae, remarkable form of male genitalia, and elongated ovipositor of female. It is represented by two very distinct species of subalpine caddis-flies, both confined, as far as is known, to the southern part of the South Island.

Tiphobiosis montana n. sp. (Plate 19, fig. 13; text-figs. 13, 14.)

♂. Total length, 3·5 mm.; forewing, 5·2 mm.; expanse, 11 mm.

Head, thorax, and *abdomen* dull-blackish; eyes black; vertex covered with pale-greyish hairs; antennae nearly as long as forewing, dark brown, basal segment swollen, two and a half times as long as second segment (text-fig. 13 *c*). the third longer and narrower than second; last segment of maxillary palpi a little longer than fourth. Legs—coxae and femora dark-brownish, tibiae and tarsi medium testaceous.



TEXT-FIG. 14.—*Tiphobiosis montana* n. g. and sp., ♂. Appendages (× 50). *a*, dorsal view; *b*, ventral view; and *c*, lateral view. Note the long process of the tenth tergite, and the lengthening of the ninth sternite. (10 per cent. KOH preparation.)

Wings.—Forewing pale testaceous, with numerous upstanding hairs of a pale-golden colour, giving the wing a slight tinge of yellowish; costal and posterior margins a little darker than rest; pterostigma 1 mm. long, darkened. From fork of Rs a cross-vein descends on to M exactly above thyridial cross-vein; a pale subhyaline space encloses these cross-veins, and another similar space occurs a little distad from from it. Hindwing subhyaline, slightly infuscated, with two cross-veins corresponding with the two mentioned above for forewing, but not quite in line with one another. Ninth sternite greatly elongated. Appendages of very remarkable

form, as shown in text-fig. 14; the process of tenth tergite and pre-anal appendages long and slender, penis shorter, with bifid apex, gonapophysis short.

♀. Very similar to male, but differing from it in the slightly darker, more fuscous forewings, and in having the abdomen produced into a semitransparent brownish ovipositor, 1·5 mm. long, carrying a number of stiff bristles directed both forward and backwards; gonapophyses ear-like, minute, 0·07 mm. long.

Types. Holotype male, Ben Lomond, Queenstown, 4,000 ft. (15th December, 1919, R. J. T.), also several paratype males taken at the same time; allotype female, Gouland Downs, 2,000 ft., Nelson Province (7th February, 1922, R. J. T.): all in Cawthron Institute collection.

Habitat.—Swampy areas in subalpine localities, South Island.

Tiphobiosis fulva n. sp. (Text-fig. 13 *b*.)

♀. Forewing, 8 mm.; expanse, 17 mm.

This species differs from the previous one in its much greater size, and also in having head clothed with rich brown hairs, forewings a deep fulvous, with few upstanding hairs of a dark colour, and venation very distinct by the much greater length of apical forks, and the non-alignment of cross-veins, as shown in text-fig. 13 *b*; also shape of apical portion of forewing is different, both margins being convex as they approach apex, whereas in *T. montana* n. sp. they are both straight. The unique type is somewhat damaged and the abdomen is missing; when captured, however, it was noted that the abdomen terminated in a very long, slender ovipositor, similar to that described for the previous species, but considerably longer.

Type. -Holotype female, unique, captured by Mr. G. V. Hudson, near a waterfall on the Humboldt Range, Wakatipu, 3,600 ft. (2nd March, 1903); in Cawthron Institute collection, presented by Mr. Hudson.

Family HYDROPTILIDAE.

Genus Zelandoptila n. g. (Text-fig. 15.)

Wings long and narrow, with long fringes, fringe of hindwing basally somewhat longer than width of wing itself. Sc short in forewing, long and close to costa in hindwing. R_1 thickened in both wings, but terminating about half-way along hindwing by turning down to join R_{2+3}. A long, narrow triangular pterostigma strongly developed in forewing. Forewing with apical forks 2, 3, 4, and 5 present, hindwing with 2, 3, and 5; no closed cells in either wing, and no cross-veins except a faint indication of one below stigma in forewing and one between Cu_2 and 1A in hindwing. Anal area very narrow, much reduced in hindwing, where Cu_2 ends well before half-way, 1A at about one-fifth, 2A half-way along 1A, and 3A appears to be absent. Tibial spurs apparently 1, 2, 1. Female with end of abdomen extended into a long and very slender ovipositor.

Genotype.—*Zelandoptila moselyi* n. sp. (New Zealand.)

As far as I know, this remarkable genus has no near relatives in any part of the world, and must be considered as a very primitive Hydroptilid type. It would appear to have originated by reduction from an already reduced Rhyacophilid type allied to *Tiphobiosis*, thus strongly supporting the view now generally held that the Hydroptilidae as a whole are a reduced offshoot of the more primitive Rhyacophilidae.

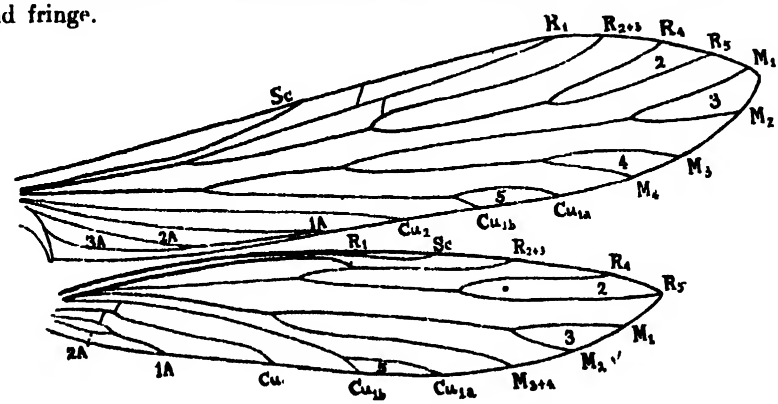
Zelandoptila moselyi n. sp. (Text-fig. 15.)

♀. Total length, 4·5 mm., inclusive of the very slender ovipositor, 1·5 mm. long; forewing, 4·8 mm.; expanse 10·5 mm.

Head dark brown, with pale hairs; eyes greyish-black; antennae about three-fourths as long as forewing, pale testaceous, strongly annulated with dark bands on each segment; palpi testaceous, darker basally.

Thorax dark brown. Legs coxae reddish-brown, rest testaceous.

Wings.—Forewing a medium fuscous, with abundant soft horizontal hairs of dark colour, and also numerous upright pale-golden hairs. Base of pterostigma dark, but distal two-thirds pale, with pale hairs above it along costa. Fringe inclined to pale golden along termen, but dull-coloured elsewhere. Hindwing somewhat infuscated, with fuscous veins and fringe.



TEXT-FIG. 15.—*Zelandoptila moselyi* n. g. and sp. Wing-venation. (For lettering see p. 314.)

Abdomen blackish-brown; ovipositor semitransparent testaceous, carrying a few stiff hairs, and with the two elongate oval gonapophyses at extreme end, exceedingly minute.

Type.—Holotype female, unique, Tokaanu, Lake Taupo, North Island (24th November, 1919, R. J. T.); in Cawthron Institute collection.

This species is dedicated to Mr. Martin H. Mosely, F.E.S., the well-known British authority on the Hydroptilidae.

Family HYDROPSYCHIDAE.

Genus HYDROPSYCHE Pictet.

Pictet, *Rech. Phrygan.*, 1834, p. 199.

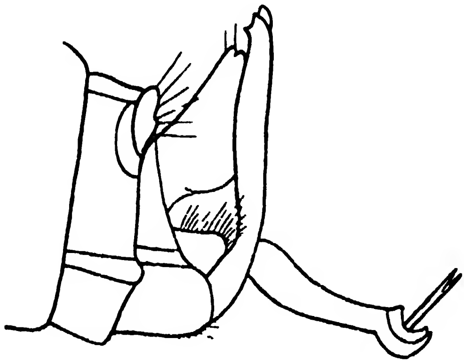
Four species of this genus are known from New Zealand—viz., *H. fimbriata* McL., *H. colonica* McL., *H. auricoma* Hare, and *H. occulta* (Hare), the last having been described by mistake as belonging to the genus *Hydrobiosis*. A fifth species is here added.

Hydropsyche philpotti n. sp. (Plate 19, fig. 8; text-fig. 16.)

♂. Total length, 5 mm., forewing, 8·3 mm.; expanse, 18 mm.

Head, thorax, and *abdomen* entirely dull-blackish; eyes black; antennae dull black, not quite as long as forewing. Appendages black with exception of the very prominent penis, which is semitransparent yellowish-brown. Legs dull-brownish.

Wings.—Forewing black in life, fading to deep fuscous in the dried specimen, scattered over wing, but especially on apical half, are numerous small rounded spots of a slightly paler colour, not at all prominently marked, and a more conspicuous pale-yellowish patch on posterior margin at end of Cu_2 and 1A. Cu_1 a stout vein, strongly marked in black. Hindwing dull fuscous, partially transparent, with darker venation.



TEXT-FIG. 16.—*Hydropsyche philpotti* n. sp., ♂. Appendages (× 45). Note the vertically upstanding gonapophyses and the remarkable penis. (10 per cent. KOH preparation.)

Text-fig. 16 shows the very characteristic genital appendages of this species, in which the gonapophyses are held vertically upright, while the remarkably shaped penis projects outwards horizontally, carrying a strong terminal lobe from which projects a slender bifid spine.

♀. Unknown.

Types.—Holotype male and three paratype males, Dun Mountain, Nelson, 3,000 ft. (8th January, 1922, A. Philpott); all in Cawthron Institute collection.

Evidently allied to *H. occulta* (Hare), but easily distinguished by its black coloration and the form of its appendages.

Family CALAMOCERATIDAE.

Up to the present no representative of this family has been recognized in New Zealand, though in Australia several species of the genus *Anisocentropus* are known, one of which extends as far south as Tasmania. I am now able to show that the very remarkable genus *Philorheithrus* Hare belongs to this family. This genus was proposed by Hare in 1910 for Hudson's species "? *agilis*," placed by that author in the family Sericostomatidae, between the genera *Pseudoeconesus* and *Olinga*. Even a cursory examination of so large an insect would show that the maxillary palpi of the male were five-segmented, a character which at once puts it out of the family Sericostomatidae. Hare, in the diagnosis of his new genus, correctly states the structure of the maxillary palpi; but he does not attempt to place the insect in any family, nor are his generic characters selected in such a way that it is possible to do so without a complete re-study of the insect itself.

The characters on which the genus *Philorheithrus* finds its place in the family Calamoceratidae are as follows: Maxillary palpi five-segmented

in both sexes (suborder Aequipalpia), the last segment not flexible or annulated, not longer than the preceding one. Ocelli absent. Median cell present in forewing. All five apical forks present in forewing. Antennae with first segment enlarged. Genital appendages of the male with strongly developed pre-anals.

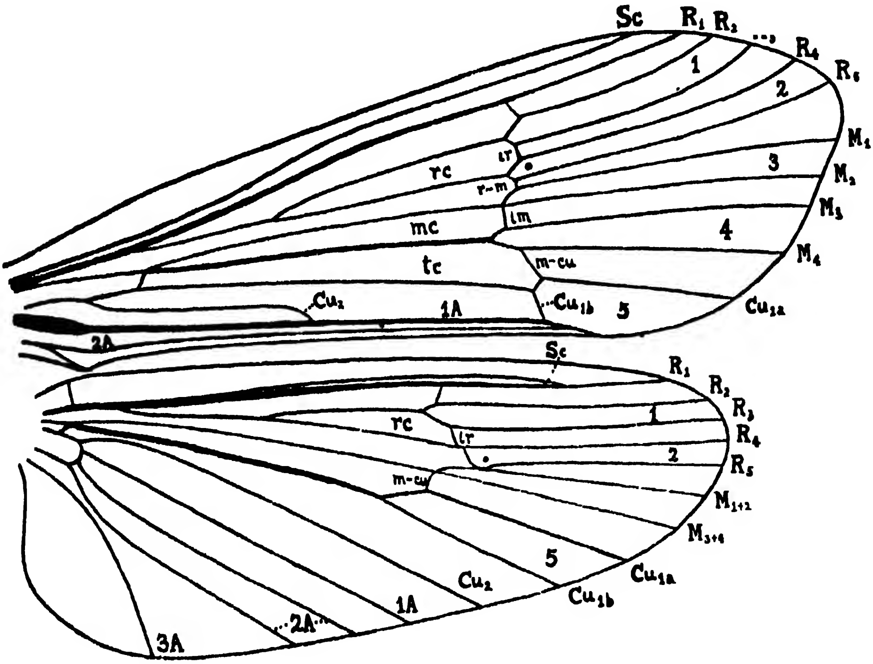
Genus PHILORHEITHRUS Hare, *nomen emendatum.* (Text-figs. 17, 18.)

Philorheithous Hare, *Trans. N.Z. Inst.*, vol. 42, p. 32, 1910.

Hare gives the derivation from ῥεῖθρον = a stream, from which it would appear that *Philorheithous* is a *lapsus calami*, or misprint for *Philorheithrus*.

The genus needs to be redefined as follows:

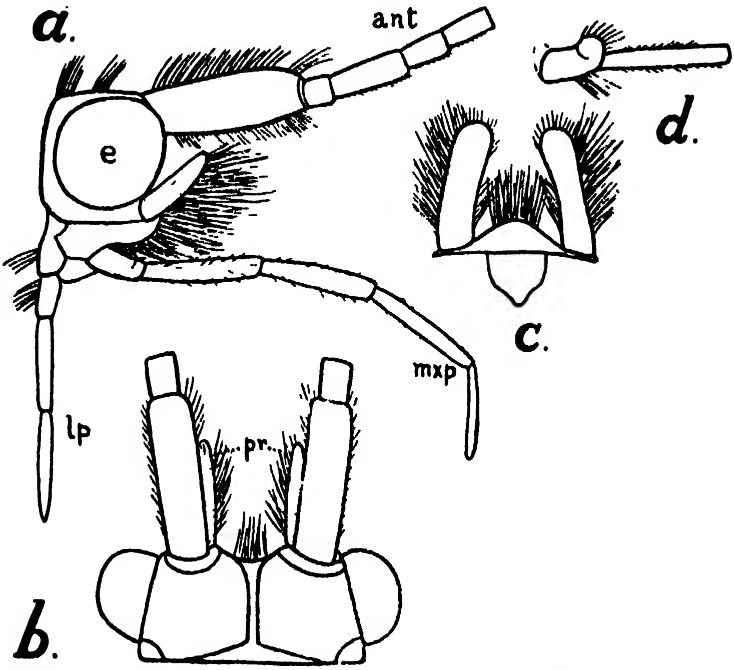
Head subrectangular, broader than long, very hairy; antennae with the first segment stout, cylindrical, as long as the next three taken together; total length of antenna about as long as that of forewing,



TEXT-FIG. 17.—*Philorheithrus agilis* (Hudson), ♂. Wing-venation. (For lettering see p. 311.)

sometimes longer, sometimes shorter. From beneath the antennae there projects, in the male only, a pair of very hairy processes, about half as long as the first antennal segment (text-fig. 18 *a c*); they appear to be homologous with the "pilifers" of Lepidoptera. Maxillary palpi with the first segment short, swollen distally on the inner side into a small knob (text-fig. 18 *d*); the succeeding three segments elongated, cylindrical, each a very little longer than the one succeeding it; distal segment distinctly narrower than rest. Labial palpi with first segment little more than half as long as second; second and third about equal.

Wings variable in shape, the forewing especially so, being sometimes very narrow, with costal and posterior margins parallel, and little or no enlargement of breadth towards apex, sometimes broadening considerably towards apex, which may be either somewhat rounded, or rather sharply pointed, or right-angled, with termen cut off squarely and distal part of costa strongly arched above it. Hindwings also very variable in size, shape, and breadth. Venation characterized by the presence of closed radial, median, and thyridial cells in forewing, and closed radial cell in hindwing; at the level marked by ends of these cells in forewing there



TEXT-FIG. 18.—*Philorheithrus agilis* (Hudson), ♂. Details of structure of the head. *a*, lateral view of head, showing eye (*e*), antenna (*ant*), maxillary palpi (*mxp*), and labial palp (*lp*); the hairy processes are seen projecting upwards and outwards below the base of the antenna. *b*, view of head from above, with first two segments of antennae only, and the processes (*pr*) partially visible beneath them. *c*, the two hairy processes, or pilifers, dissected out to show their relationship with the small triangular labrum, situated between them. *d*, first two segments of maxillary palp, showing the swollen knob on segment 1 distally. (All figures × 22.)

is developed, by means of additional cross-veins, a complete *transverse cord* or anastomosis of the veins, such as is frequently met with in the family Limnephilidae. Anal area of forewing excessively narrowed, vein 1A very strongly formed, and greatly thickened at base. Hindwing with apical forks 1, 2, and 5; Sc more or less fused with R_1, anal area somewhat expanded.

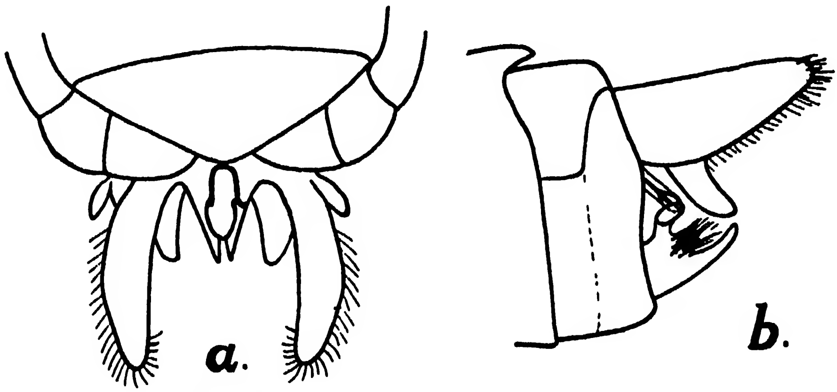
Tibial spurs 2, 4, 4. Male genital appendages with strong, forcipate pre-anal appendages and short gonapophyses. Female without elongation of terminal abdominal segment; gonapophyses well developed as stout lobes.

Genotype.—*Philorheithrus agilis* (Hudson). (New Zealand.)

Two species of this genus are known from New Zealand, one of which is here described for the first time. There are also to be found in eastern Australia and Tasmania closely similar insects, none of which have so far been described.

Philorheithrus agilis (Hudson). (Plate 19, fig. 9; text-figs. 17–19.)

In size this is one of the most variable insects known to me; female specimens in the Cawthron Institute collection vary from 21 mm. to 37 mm. in expanse, and the male is almost as variable. The shape of the wings and the distinctness of the colour-pattern are also very variable. Plate 19, fig. 9, is taken from a strongly-marked and rather broad-winged form. Text-fig. 18 shows the interesting structure of the head and mouth-parts; text-fig. 19 two views of the male genitalia after treatment with 10 per cent. KOH solution (in the dried specimen the pre-anal appendages appear somewhat more forcipate); and text-fig. 17 shows the venation of the male, that of the female being practially the same.



TEXT-FIG. 19.—*Philorheithrus agilis* (Hudson), ♂. Appendages (× 30). *a*, dorsal view; *b*, lateral view. Note the strongly developed pre-anals. (10 per cent. KOH preparation.)

Type in Mr. G. V. Hudson's collection (sex not stated; probably a male).

Habitat.—Provinces of Wellington, Nelson, and Canterbury; local, but abundant in places; found on fast-running mountain-streams.

Philorheithrus lacustris n. sp. (Plate 19, fig. 10.)

♂. Total length, 8 mm.; forewing, 14 mm.; expanse, 29 mm.

Morphologically very close to *Ph. agilis* (Huds.), from which it may at once be distinguished by pointed apex and evenly-rounded termen of forewing, much more elongated hindwing with narrowed apex, stronger arching of costa of forewing near base, absence of any definite colour-pattern on wing, forewings being a dull medium fuscous, darker towards apices, with a slightly paler mark on pterostigma, hindwings semitransparent greyish, tinged yellowish-pink along costal margin. Appendages rather similar those of *Ph. agilis*, pre-anals forming a stout forceps, but gonapophyses not projecting at all as in that species, and excessively short.

♀. Unknown.

Types. Holotype and paratype males, Lake Wakatipu, at Kingston, (13th December, 1919, R. J. T.); both in Cawthron Institute collection.

Habitat. Shores of Lake Wakatipu; very rare. The cases and larvae were found attached to rocks near the shore, showing that the larval habitat of this species differs greatly from that of its relative *Ph. agilis.* There is a species closely resembling this, but not yet described, which is very abundant around the shores of the three lakes of the Cradle Mountain massif, in north-west Tasmania.

Family LEPTOCERIDAE.

Genus Triplectides Kolenati.

Kolenati, *Gen. et Spec. Trichopterorum*, vol. 2, p. 247, 1859.

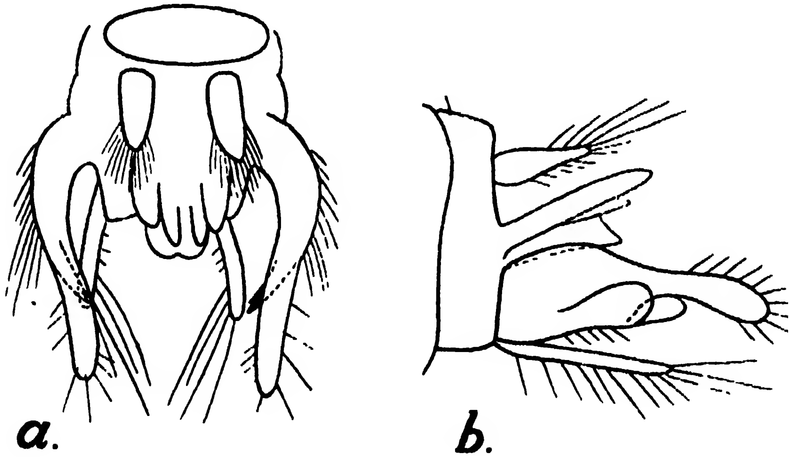
Genotype.— *T. gracilis* (Burm.), Brazil.

This genus is very closely allied to *Notanatolica* McLach., from which it differs only in having the tibial spurs 2, 2, 1, instead of 2, 2, 2, or 0, 2, 2.

Triplectides oreolimnetes* n. sp. (Plate 19, figs. 11, 12; text-fig. 20.)

♂. Total length, 6 mm.; forewing, 10 mm.; expanse, 21 mm.

Head fuscous, with pale-grey hairs; eyes medium greyish; antennae fuscous, 22 mm. long, very slender, but basal segment swollen and carrying pale-grey hairs; palpi fuscous.



Text-fig. 20.—*Triplectides oreolimnetes* n. sp., ♂. Appendages (× 50). *a*, dorsal view; *b*, lateral view. (10 per cent. KOH preparation.)

Thorax and *abdomen* fuscous shading to brownish. Legs -forelegs dark fuscous, with short, dark tibial spurs; middle and hind legs pale testaceous, including spurs. Genital appendages as shown in text-fig. 20, the pre-anals very short, the gonapophyses long, with a strong bifid claw-like process developed from middle of ventral surface; beneath gonapophyses there are developed two straight, cylindrical ventral processes about two-thirds their length.

* Greek ὄρος, a mountain; λίμνη, a lake.

Wings.—Forewing medium fuscous, somewhat transparent in places, and more or less strongly mottled with whitish or greyish. Pterostigma with whitish or greyish patch; R_1, Cu_1, and 1A strongly mottled with whitish. Distal third of wing mottled with patches of greyish-white hairs which tend to become arranged in three transverse rows across wing. Hindwing subhyaline, somewhat infuscated distally; venation fuscous.

Types. - Holotype male, allotype female, and series of seven paratype males, all from Gouland Downs, Nelson Province (7th February, 1922, R. J. T.), 2,000 ft. Also a single male, slightly larger, from Mount Arthur Tableland (20th February, 1921, A. Philpott), 4,500 ft. All the above in Cawthron Institute collection.

♀. Very similar to male, but with shorter antennae and wings; expanse only 18 mm.; abdomen stouter than in male; hindwings less transparent.

This species is fairly closely related to *T. obsoleta* McL., from which it is distinguished at once by its very much smaller size, duller coloration, and differently-shaped male genitalia. It appears to be confined to elevated localities in the South Island, where it is to be found sitting on the reeds or bushes fringing small mountain-tarns. The larva has the very characteristic habit of forming its case out of small particles of micaceous matter selected from the bottom of the tarns; the case itself is very narrow subcylindrical in shape, and can generally be detected only by the glint of the sun on the micaceous particles when the larva moves.

Family SERICOSTOMATIDAE.

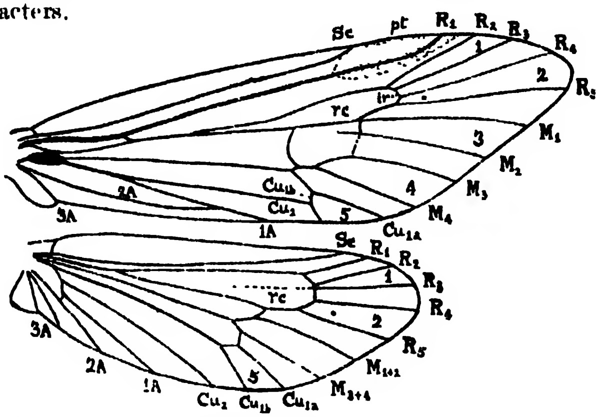
This family is in many respects the most highly evolved in the whole order, being marked by numerous specializations in the wing-venation, the form of the antennae, and more especially in the structure of the maxillary palpi of the male, these being reduced to four, three, or even only two segments, and specialized so as to be of quite different form from those of the female. The family is well represented in New Zealand, no less than ten species being known, belonging to seven genera. Six new species are here added, and one new genus is proposed for the reception of four of them.

Genus PYCNOCENTRODES n. g. (Text-fig. 21.)

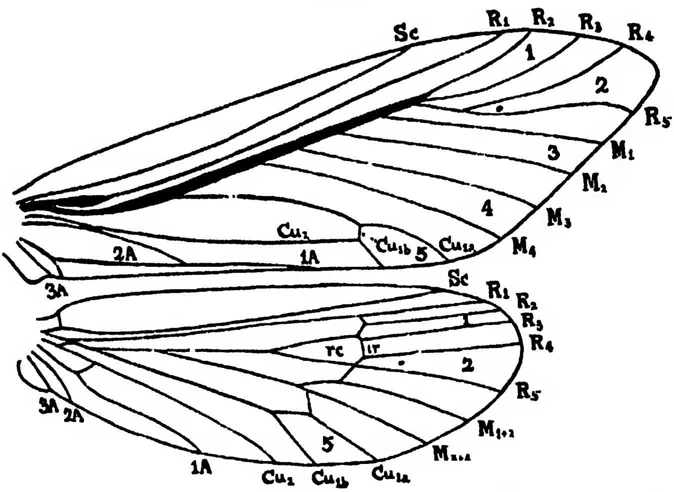
Allied to *Pycnocentria* McL., from which it differs by the absence of the longitudinal fold in forewings of male, and the consequent normal structure of the radial sector in both sexes. The radial cell is present, and is of a somewhat narrowed, elongate form, basal portion being particularly narrowed. In some cases the stem of R_{2+3} may be weakened or obsolescent, so that the radial cell is incomplete above (as in *P. olingoides* n. sp.), but venation is always very distinct from that of *Pycnocentria* (text-fig. 22), where all the branches of Rs, M, and Cu_1 come off direct from longitudinal fold. Stem of R_{2+3} in hindwing of male also weakened or obsolete, leaving radial cell open above. Apical forks of forewing all present, as in *Pycnocentria*; in hindwing, only 1, 2, and 5 present, as also in *Pycnocentria*. No longitudinal fold in hindwing of male. Tibial spurs 2, 2, 4. Maxillary palpi of male short and hairy, not projecting beyond end of first antennal segment.

Genotype.—*Pycnocentrodes chiltoni* n. sp. (New Zealand.)

The differences between the venations of males of *Pycnocentria* and the new genus can be seen at once by comparing text-figs. 21 and 22. The females resemble one another very closely both in venation and in other characters.



TEXT-FIG. 21.—*Pycnocentrodes chiltoni* n. g. and sp., ♂. Wing-venation. (For lettering see p. 314.)



TEXT-FIG. 22.—*Pycnocentria evecta* McL., ♂. Wing-venation, for comparison with text-fig. 21. Note the longitudinal groove in the forewing. (For lettering see p. 314.)

Four new species belonging to this genus may be distinguished by the following key:—

1. Smaller species, the males expanding about 12 mm. to 14 mm. ..	2
Larger species, the males expanding about 19 mm. to 22 mm., and having a general superficial resemblance to *Olinga feredayi* McL.	3
2. Forewing a medium brownish-testaceous, with an area of pale golden-yellow hairs forming a faint fascia below pterostigma and descending as far as Cu_{1b}	*P. chiltoni* n. sp.
Forewing nearly black in life, dark fuscous in the dried insect, with bright golden patches near base and also in the wedge-shaped area between Cu_1, Cu_{1b}, and 1A	*P. pulchella* n. sp.
3. Hairs of forewing uniformly fulvous; penis of male deeply bifid	*P. olingoides* n. sp.
Hairs of forewing almost entirely fuscous; penis of male not bifid	*P. hamiltoni* n. sp.

Pycnocentrodes chiltoni n. sp. (Plate 19, fig. 14; text-figs. 21, 23.)

♂. Total length, 4·5–5 mm.; forewing, 7–8 mm.; expanse, 13·5–16 mm. This insect shows a strong superficial resemblance to *Pycnocentria evecta* and *P. aureola* McL., its general form and coloration being much the same. It may be distinguished from them at once as follows: In both sexes the antennae are pale testaceous, strongly annulated with fuscous on all segments, and the pale-golden scaling of the forewing does not extend all over the wing, but is confined to the subcosta, the cubito-anal area, and a fascia extending across the wing from the pterostigma to Cu_{1b}; in fresh specimens there is an irregular area slightly darker than the rest of the wing, just basad from this fascia, and sometimes curving round it in the form of the letter C. The male can at once be distinguished further by the absence of the darkly shaded longitudinal band of the forewing which is characteristic of the genus *Pycnocentria*. The female expands 16 18 mm., and is thus considerably larger than the male, but not so large as the female of *Pycnocentria evecta*. It resembles the male fairly closely, but the wings are of a paler colour, with a larger area covered with pale-golden hairs.

TEXT-FIG. 23.—*Pycnocentrodes chiltoni* n. g. and sp., ♂. Appendages (× 55). Lateral view. Note the bilobed gonapophysis and the soft membranous penis with chitinous lateral processes. (10 per cent. KOH preparation.)

Text-fig. 23 shows a lateral view of the male appendages, after maceration in 10 per cent. KOH solution. The soft, everted penis, with lateral chitinous processes, is not visible in the dried insect. The gonapophyses are bilobed.

Types. - Holotype male and series of three paratype males, Cass, Canterbury (6th January, 1920, R. J. T.); allotype female, and series of three paratype females and one male, Nelson (allotype, 29th November, 1920, A. Philpott): all in Cawthron Institute collection.

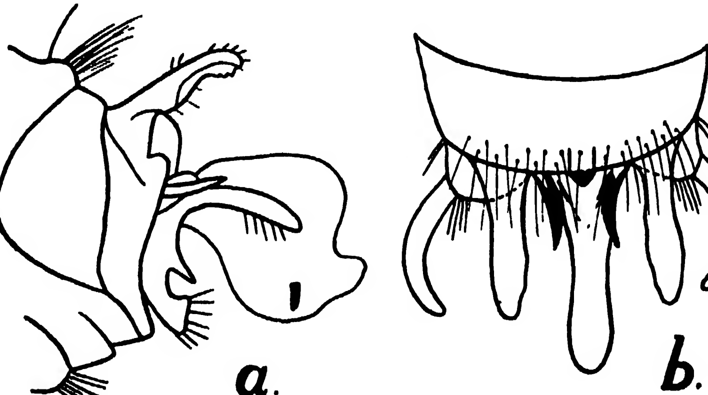
Habitat.--All parts of the South Island; not uncommon. I have specimens also from Dunedin; the females of the latter are of a pale testaceous colour, but this may be due to their having been taken late in the season. The resemblance of this insect to *P. evecta* has probably caused it to be overlooked, as has been the case with *P. aureola* also.

This insect is dedicated to my friend Dr. C. Chilton, Professor of Biology, Canterbury College, Christchurch, through whose kindness I was enabled to visit the Cass Biological Station, near which this insect was first discovered.

Pycnocentrodes pulchella n. sp. (Plate 19, fig. 15; text-fig. 24.)

♂. Total length, 3·5 4 mm.; forewing, 6-7 mm.; expanse, 13 15 mm.

Easily recognized by its dark-fuscous wings (almost black in life), forewing having a patch of bright golden hairs at base and another extending outwards so as to fill wedge-shaped area between Cu_1, Cu_{1b}, and 1A. The antennae have the large basal segment fuscous, the rest rich pale brown annulated with darker brown. The epicranium carries a number of long golden hairs. Thorax and abdomen black; appendages brownish, shaped as in text-fig. 24.



TEXT-FIG. 24.- *Pycnocentrodes pulchella* n. sp., ♂. Appendages (× 55). *a*, lateral view; *b*, dorsal view. Compare text-fig. 23. (10 per cent. KOH preparation.)

Types.—Holotype and three paratype males, Lumsden, Southland, (13th December, 1919, R. J. T.); all in Cawthron Institute collection. The insect was discovered sitting on the rushes and reeds fringing a tiny streamlet near the railway-station; no females were seen. Mr. W. G. Howes, of Dunedin, was present with me when they were taken. No other locality is yet known for this very beautiful little caddis-fly.

Pycnocentrodes olingoides n. sp. (Plate 19, fig. 16; text-fig. 25 *a*.)

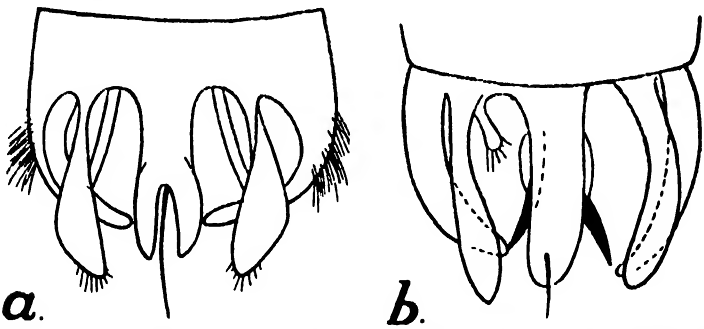
♂. Tota length, 5 mm.; forewing, 10 mm.; expanse, 21·5 mm.

Head, *thorax*, and *abdomen* brown; the epicranium with rich golden hairs; antennae three-fourths as long as forewing, fulvous annulated with darker brown; mouth-parts entirely fulvous. Legs entirely fulvous.

Wings. Forewing covered with short fulvous hairs; veins rich brown. Hindwing subhyaline, slightly infuscated, with rich brown venation, and pulvous hairs along Sc and R_1; fringe along costa to apex fulvous, along posterior border pale-greyish. Anal appendages of the dried insect as in text-fig. 25 *a*, pre-anals rather broadly foliate, with narrow bases; penis deeply bifid, and carrying a long projecting bristle nearly twice as long

as each lobe of the bifurcation; gonapophyses rather short, forcipate. Sternite 8 with a broad process extending from it.

♀. Closely resembling the male both in size and colour, but at once distinguished from it by the slender, five-segmented maxillary palpi and absence of the complicated genital appendages; forewings also are slightly narrower at base.



TEXT-FIG. 25.—Male genital appendages, dorsal view, of *a*, *Pycnocentrodes olingoides* n. sp.; *b*, *Pycnocentrodes hamiltoni* n. sp. Drawn from the dried insect. (× 45.)

Types.—Holotype male and allotype female, Gouland Downs, Nelson Province (7th February, 1922, R. T. J.); both in Cawthron Institute collection; also a paratype male from same locality.

Both sexes of this insect very closely resemble female of *Olinga feredayi* McL.; hence the specific name given. They are best distinguished from it by the more fuscous hindwings of the latter, and by the fact that in the genus *Olinga* many of the hairs of the forewings are flattened down into the form of narrow scales.

Pycnocentrodes hamiltoni n. sp. (Plate 19, fig. 17; text-fig. 25 *b*.)

Closely similar in size and shape to the preceding species, but the male can at once be distinguished by the colour of wings, which are semi-transparent brownish-fuscous, with numerous short brown hairs, and a long patch of golden hairs occupying the cubito-anal space of forewing. The wings also show some pinkish-brown iridescence. The antennae are pale yellowish-brown, with medium brown annulations; the abdomen is pale olive-green; legs yellowish-brown; appendages dark brown, shaped as shown in text-fig. 25 *b*; penis not bilobed, but with a short bristle projecting from near its end, and a pair of large sharp spines standing out on either side of it; the pre-anals less broadly foliaceous than in preceding species; gonapophyses forcipate, somewhat stouter than in preceding species. The eighth sternite carries a process. Female very closely similar to that of preceding species, but having termen of forewing slightly more arched, and radius more strongly curved within pterostigma; also abdomen shows a tinge of greenish. From female of *Olinga feredayi* it can at once be distinguished by the difference of venation: radius in *Olinga* runs straight through pterostigma, and curvature of branches of M and Cu is different.

Types.—Holotype male and allotype female, Pouto River, between Tokaanu and Lake Roto-Aira, North Island (27th November, 1919); both in Cawthron Institute collection.

This species is dedicated to my friend Mr. Harold Hamilton, Zoologist to the Dominion Museum, Wellington, who was present with me when the insects were taken.

Genus HELICOPSYCHE Hagen.

Hagen, *Entom. Monthly Magazine*, vol. 2, p. 252, 1866.

This very widespread genus is remarkable for the peculiar formation of the branches of the media in both wings. In the forewing, M_2 and M_3 are fused together for some distance basally, thus forming an apparent apical fork between them when they diverge distally, much in the same way as has been described above for males of the genus *Neurochorema.* In the hindwing, where M_4 is absent, this same fusion takes place between M_2 and M_{3+4} basally, and results in the apparent presence of three veins, M_{1+2}, M_3, and M_4, though these are actually M_1, M_2, and M_{3+4} respectively. This transference of vein M_2 on to a common stalk with M_{3+4} in this wing led Ulmer to state that Af_4 was present in the hindwing of this genus and of the allied Australian genus *Saetotricha.* As a matter of fact, Af_4 is never present in the hindwing of any Trichopteron, since M_4 never exists as a separate vein.

The larval characteristics of the genus are well known, the generic name having been given from the helicoid form of the case, which is composed of grains of sand, and is so beautifully modelled as to appear almost exactly like a small snail-shell. To accommodate itself to its peculiar home the larva has become greatly elongated.

Genotype.—Helicopsyche borealis Hagen. (North America.)

Only a single species has so far been recorded from New Zealand—viz., *H. zelandica* Hudson (Plate 19, fig. 18)—more fully described by Hare in 1910, Hudson's original description being very scanty. Two more species are here added, making three for the Dominion. They may be distinguished by the following key:—

1. Wings dark fuscous or blackish	*H. zelandica* Huds.
Wings very pale greyish	2
2. Smaller species, expanding 9–10 mm., the wings unicolorous whitish grey, without any markings: process of tenth tergite of male narrower at apex than at base, the tip triangularly excavated	*H. albescens* n. sp.
Larger species, expanding 11–12 mm., the wings pale-greyish, with slight indications of some paler markings on forewing; process of tenth tergite of male as broad at apex as at base, the tip strongly truncated	*H. howesi* n. sp.

Helicopsyche albescens n. sp. (Plate 19, fig. 19; text-fig. 26.)

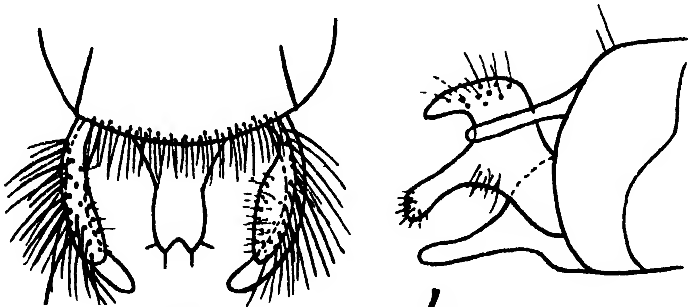
♂. Total length, 3 mm.; forewing, 4·5 mm.; expanse, 9·5 mm.

The whole of the *head*, *thorax*, and *abdomen* dull brownish-testaceous, except eyes, which are blackish, and antennae, which are testaceous; legs pale greyish-testaceous.

Wings semitransparent whitish, with very pale greyish hairs and fringe; venation pale-greyish. Appendages of very characteristic form, as may be seen from text-fig. 26; process of tenth tergite wider at base than at apex, and the latter triangularly incised and carries four short stiff bristles; pre-anals short and slender; gonapophyses very large, two-branched, and exceedingly hairy.

Types.—Holotype male, allotype female, and series of paratype males, Purau Creek, Lyttelton Harbour (3rd January, 1920, R. J. T.); all in Cawthron Institute collection.

Habitat. — South Island: Canterbury and Nelson Provinces. The species occurs commonly around Nelson, but I have taken only males so far.



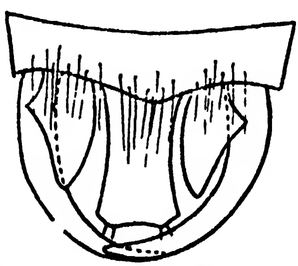
TEXT-FIG. 26. –*Helicopsyche albescens* n. sp., ♂. Appendages (× 84). *a*, dorsal, view; *b*, lateral view. Note the bilobed gonapophysis in *b*. (10 per cent. KOH preparation).

Helicopsyche howesi n. sp. (Plate 19, fig. 20; text-fig. 27.)

♂. Total length, 3·5 mm.; forewing, 5·5 mm.; expanse, 11·5 mm.

Head, thorax, and *abdomen* dull brownish-testaceous; antennae testaceous, with basal segment darker, fuscous; epicranium with long fuscous hairs. Legs very pale testaceous.

Wings pale-greyish, with slightly-indicated paler whitish patches on forewing at one-third from base, near costa, and at two-thirds from base, below pterostigma, also a little before pterostigma and distally between M and Cu_1. Hairs and fringe greyish, with slight tinge of brown. Appendages of dried insect as shown in text-fig. 27; the process of tenth tergite as broad at apex as at base, the tip strongly truncated; pre-anals short, subtriangular, angulated externally not far from bases; gonapophyses much larger, appearing strongly forcipated when viewed from above.



TEXT-FIG. 27.—*Helicopsyche howesi* n. sp., ♂. Appendages (× 84), dorsal view, for comparison with text-fig. 26. Drawn from the dried insect.

♀. Unknown.

Type.—Holotype male, unique, Dunedin (1st January, 1920); in Cawthron Institute collection. The larvae were plentiful in the streams, and their cases are larger and composed of coarser sand-grains than those of the other two species. Mr. W. G. Howes has, I believe, succeeded in rearing this species several times.

This species is dedicated to my friend Mr. W. G. Howes, whose guest I was at the time the insect was taken, and whose keen work on aquatic and other insects is well known to all entomologists in the Dominion.

Explanation of the Comstock-Needham Notation used in the Text-figures illustrating Wing-venation.

The numerals 1, 2, 3, 4, 5 indicate the five apical forks of the wing, usually designated in the text as Af_1, Af_2, Af_3, Af_4, and Af_5 respectively.

1A, 2A, 3A, the three anal veins; in the forewings of Trichoptera they become looped up to form a double Y-vein.

Cu, cubitus. Cu_1, first cubitus, branching into Cu_{1a} and Cu_{1b}, between which is enclosed the fifth apical fork, Af_5.

hm, humeral veinlet. *im*, inter-median cross-vein. *ir*, inter-radial cross-vein. *jl*, jugal lobe (in Rhyacophilidae).

M, media. In forewing it has four branches, M_1, M_2, M_3, M_4 respectively, of which the first two enclose the third apical fork, Af_3, while the third and fourth enclose the fourth apical fork, Af_4. In the hindwing it has only three branches, M_1, M_2, and M_{3+4} respectively, and hence Af_4 is never present in that wing.

m-cu, medio-cubital cross-vein. *mc*, median cell, closed distally by the cross-vein *im*. *pt*, pterostigma.

R, radius. R_1, its main stem. Rs, radial sector, with its four branches R_2, R_3, R_4, R_5 respectively; of these, R_2 and R_3 together enclose the first apical fork, Af_1, while R_4 and R_5 together enclose the second apical fork, Af_2; the wing-spot is found in the angle of this latter fork.

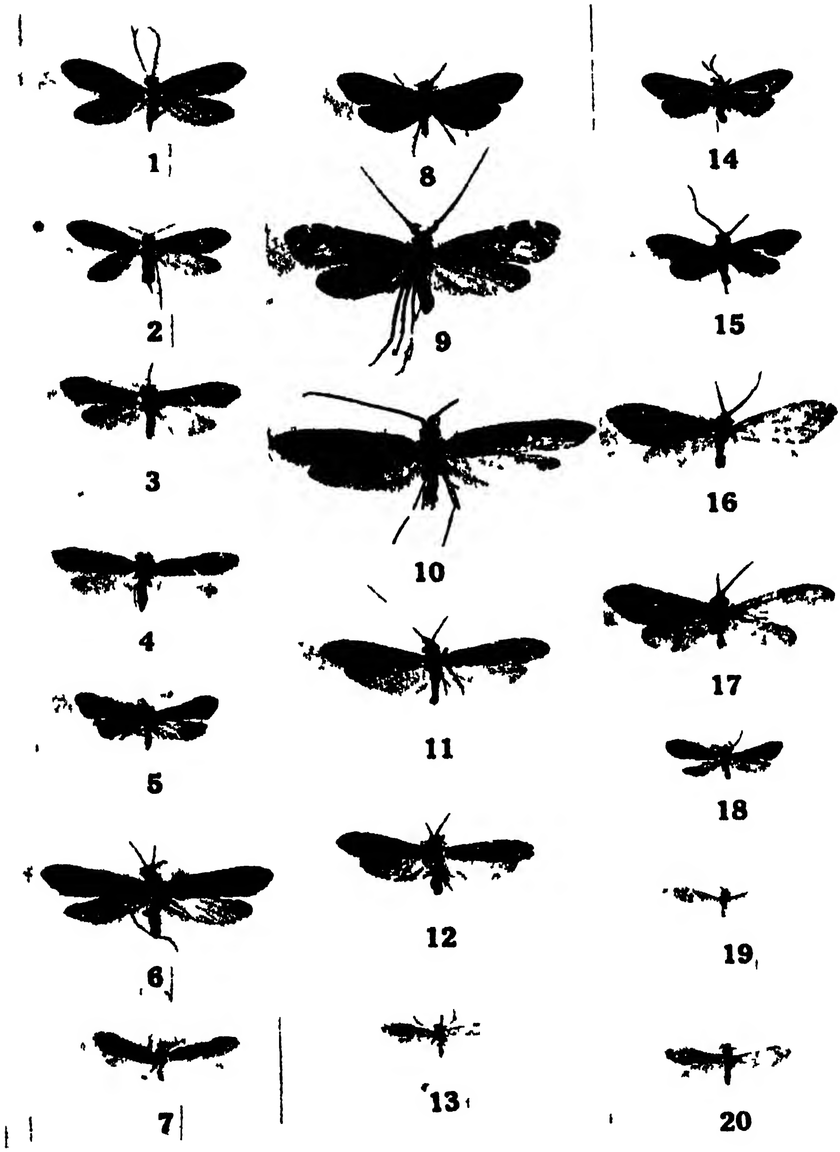
r-m, radio-median cross-vein. *rc*, radial cell, closed distally by the inter-radial cross-vein *ir*.

Sc, subcosta. *tc*, thyridial cell, closed distally by the medio-cubital cross-vein *m-cu*.

Explanation of Plate 19.

Fig. 1.—*Hydrobiosella stenocerca* n. g. and sp. Holotype male.
Fig. 2.—*Hydrobiosella stenocerca* n. g. and sp. Allotype female.
Fig. 3.—*Neurochorema decussatum* n. g. and sp. Holotype male.
Fig. 4.—*Neurochorema decussatum* n. g. and sp. Allotype female.
Fig. 5.—*Hydrochorema crassicaudatum* n. g. and sp. Holotype male.
Fig. 6.—*Hydrochorema tenuicaudatum* n. sp. Holotype female.
Fig. 7.—*Synchorema zygoneura* n. g. and sp. Holotype male.
Fig. 8.—*Hydropsyche philpotti* n. sp. Holotype male.
Fig. 9.—*Philorheithrus agilis* (Hudson). Rather broad-winged and well-marked male from Gouland Downs.
Fig. 10.—*Philorheithrus lacustris* n. sp. Holotype male.
Fig. 11.—*Triplectides oreolimnetes* n. sp. Holotype male.
Fig. 12.—*Triplectides oreolimnetes* n. sp. Allotype female.
Fig. 13.—*Tiphobiosis montana* n. g. et sp. Holotype male.
Fig. 14.—*Pycnocentrodes chiltoni* n. g. and sp. Holotype male.
Fig. 15.—*Pycnocentrodes pulchella* n. sp. Holotype male.
Fig. 16.—*Pycnocentrodes olingoides* n. sp. Holotype male.
Fig. 17.—*Pycnocentrodes hamiltoni* n. sp. Holotype male.
Fig. 18.—*Helicopsyche zelandica* Hudson. Specimen from Karori, Wellington (Nov. 30, 1919, R. J. T.).
Fig. 19.—*Helicopsyche albescens* n. sp. Specimen from Nelson (Jan. 1, 1921, A. Philpott).
Fig. 20.—*Helicopsyche howesi* n. sp. Holotype male.

All the figures in the plate are magnified 1·3 diameters.



The New Zealand Plant-hoppers of the Family Cixiidae (Homoptera).

By J. G. MYERS, B.Sc., F.E.S., Biology Laboratory, Department of Agriculture.

[*Read before the Wellington Philosophical Society, 25th October, 1922; received by Editor, 31st December, 1922; issued separately, 18th June, 1924.*]

Plates 20–24.

IN that large division the Fulgoroidea, the most largely represented family in New Zealand, both in species and in individuals, is the Cixiidae. At the present time the Fulgoroids of New Zealand are contained in seven families, eighteen genera, and twenty-nine species. Of this total the Cixiidae claims eight genera and seventeen species, so that even with our present extremely rudimentary knowledge of the New Zealand Homoptera it is safe to say that the Cixiids are the dominant Fulgoroids of this region.

The object of this paper is to give an up-to-date revision of the family, and to describe new genera and species. Such a revision can be only provisional, as the number of new forms yet undescribed is very probably large.

I wish to express my deep gratitude to Mr. Frederick Muir, of Honolulu, who has helped me with keys to genera and with much other assistance from his wide homopterological experience. He has also compared my species with Walker's types in the British Museum, and has thus enabled this paper to be more thoroughly revisional than it could possibly have been without such a comparison. For all the photographs I am indebted to Mr. W. D. Reid, of this Laboratory, who spared no pains to produce the very best results that my dissections and mounts would allow. The three drawings of the face in the genera *Koroana*, *Cixius*, and *Huttia*, showing points for which my draughtsmanship was quite inadequate, were executed by Mr. E. H. Atkinson, who is also one among the many collectors who have sent me Homoptera from all parts of the Dominion.

The genitalia were dissected and mounted in the manner recommended by Giffard and Muir.* The card mounts, made with the help of two cover-slips, and kept on the same pin with the insect, were found extremely convenient, and served every purpose when drawing was done with a camera lucida. When, however, the genitalia were microphotographed it was found that ordinary glass slide mounts, besides being easier to handle, gave much better results.

The Cixiidae are easily collected by beating bushes and by sweeping herbage. More specimens from out-of-the-way localities and from islands are urgently desired. They should be killed with cyanide or laurel, and stored dry, without pinning, and may be kept indefinitely, or sent through the post in pill-boxes with a little soft paper. Like all small or medium-sized Auchenorrhyncha, they should be gummed transversely on small card triangles for the collection.

The biology of the New Zealand species is almost unknown. Mr. G. V. Hudson reared *Oliarus oppositus* (Walk.) from a cottony-tailed nymph

* WALTER M. GIFFARD, The Systematic Value of the Male Genitalia of Delphacidae (Homoptera), *Annals Ent. Soc. Am.*, 14, No. 2, June, 1921, 135–40.

found under a log. I have found nymphs of the same species, in company with those of *Koroana arthuria* n. sp., very numerous under stones, in some cases with small ants (*Monomorium* sp.) in the boulder-strewn river-bed at Arthur's Pass (2,300 ft. elevation). There is a fruitful subject of study here not only in regard to the nymphs themselves, but in their relationships with the ants. Swezey* has written an account of the life-history of the Hawaiian *Oliarus koanoa* Kirkaldy. This species spends the nymphal instars "among the decaying leaf-bases and fibrous matter of tree-fern trunks, in cavities or tunnels lined with a white fibrous material which resembled mould, or spider's web, and which is an excretion from the terminal abdominal segments of the nymphs. The nymphs probably feed upon the fern-roots in the fibrous mass of the outside of the fern trunks, or on juices of the decaying material." In North America, according to Osborn, *Myndus radicis* lives in similar crevices lined by the fibrous material of the abdominal tufts. Swezey also quotes Townsend to the effect that *Oecleus decens* lays its eggs in punctures in the leaves of *Yucca*, each puncture being covered by white fibrous matter.

The Cixiidae are moderately-sized plant-hoppers occurring often in considerable numbers on herbage and bushes, from the mangrove swamps, through forest and tussock, up to the subalpine scrub. The tegmina are folded in a roof-like manner, or in some cases almost approaching the horizontal position over the back. In addition to flying readily by means of the usually ample tegmina and wings, these plant-hoppers use their long and strong metathoracic legs in agile leaping. A leap, in fact, is their usual method of launching into the air. The tendency to brachyptery, so frequent in other families -as, for example, the Delphacidae is in the Cixiidae but little marked. The peculiar genus *Aka* has the shortest tegmina among the New Zealand forms, but its wings, although fairly short, are broad and ample.

The principal characters of the family may be summed up as follows: Width of head, including eyes, distinctly less than width of pronotum. Ocelli three, median one sometimes practically obsolete, but usually quite well developed. In a few foreign forms the median eye is absent. Pronotum very short, strongly subangularly notched behind (*Edwards*). Tegmina usually large, more or less transparent. Veins strong, macrotrichia conspicuous in many cases. Apical parts of tegmen not reticulate. Subcosta and radius with common stem. In some foreign forms Sc, R, and M are all separate, and in some others all three form a common stalk. Anal area of wing not reticulate except in Meenoplinae. First joint of hind tarsus elongate. Female of many genera bears a tuft of cottony or waxy fibrous material at the end of the abdomen, secreted by the more or less vertical plate-like area, the pygophor, between anal segment and ovipositor.

The first Cixiids from New Zealand were described by Francis Walker in 1850 and 1858. He placed in the genus *Cixius* the seven species known to him, of which two were removed by Buchanan White in 1879 to *Oliarus*, and a third was made the type of a new genus, *Aka*. Of the remaining four of Walker's species Buchanan White knew nothing, but on another new Cixiid from New Zealand he erected the genus *Semo*.

* O. H. Swezey, Observations on the Life-history of *Oliarus koanoa* Kirkaldy, *Proc. Hawaiian Ent. Soc.*, 1, pt. 3, pp. 83–84, 1907.

After numerous attempts by Mr. Muir and myself to accommodate all the New Zealand species in these and other known genera, it was decided that, rather than stretch unduly the limits of genera already inconveniently crowded, it would be best to erect four new genera by means of which the relationships of our new forms might be better expressed. To differentiate these new genera Mr. Muir drew up the following key, which for a considerable time I have tested on large series of specimens. The genera have been further differentiated, and the suggested classification shown to be natural, by dissection of the male genitalia of all species in which males were procurable.

All measurements are from apex of vertex to anus, and from base to apex of one tegmen.

KEY TO GENERA OF NEW ZEALAND CIXIIDAE.

1.	(12.)	One or more spines on the hind tibiae, not counting apical spines.	
2.	(7.)	Five mesonotal carinae, the intermediate two sometimes faint.	
3.	(6.)	Face with a median longitudinal carina.	
4.	(5.)	Carinae at apex of vertex and base of face distinct. Two transverse carinae on vertex, one dividing face from vertex and one basad of this, the latter straight and transverse, curved, or forming an angle and touching the anterior transverse carina	*Oliarus.*
5.	(4.)	Carina at apex of vertex and base of face obscure or missing; median frontal carina forked about middle of face	*Malpha*
6.	(3.)	Face without a median longitudinal carina	*Huttia*
7.	(2.)	Three mesonotal carinae, the middle one sometimes obscure.	
8.	(9.)	No median longitudinal carina on face; fronto-clypeal suture arcuate; clypeus swollen or rounded	*Semo.*
9.	(8.)	A distinct longitudinal median carina on face.	
10.	(11.)	A median longitudinal carina on vertex; clypeus fairly flat with a distinct median carina	*Cixius.*
11.	(10.)	No median longitudinal carina on vertex; clypeus fairly rounded without median longitudinal carina. Cu_1 joining M_{3+4} for a short distance	*Koroana*
12.	(1.)	No spines on hind tibiae, except apical ones.	
13.	(14.)	Vertex with a longitudinal carina forked at apex, median carina on face forked or thickened on basal half	*Aka.*
14.	(13.)	Longitudinal carina on vertex very short, not forked: median frontal carina not forked	*Tiriteana.*

Genus 1. CIXIUS Latreille.

Type: *C. nervosus* (Linn.)

This almost cosmopolitan genus is sufficiently characterized in the above key. The male genitalia of the New Zealand forms are comparatively simple. The aedeagus is straight, with backwardly-directed hooks.

Cixius punctimargo Walker. (Plate 20, figs. 1–4.)

Walker, List Homopt. Insects in *Brit. Mus. Suppl.*, p. 81, 1858. Buchanan White, *Ent. Mo. Mag.*, vol. 15, p. 216, 1879. Hutton, *Trans. N.Z. Inst.*, vol. 30. p. 186, 1898; *Index Faunae Nov. Zeal.*, p. 224, 1904. Kirkaldy, *Trans. N.Z. Inst.*, vol. 41, p. 28, 1909.

♂. Length, 3 mm.; tegmen, 4 mm. Very pale olive, the veins and tegmina malachite-green. Eyes brownish. Below brown; clypeus darker; fronto-clypeal suture black. Tegmina hyaline. Veins green, black and thickened at tips. Apical cross-veins black and thick. Stigma hyaline or whitish. Medio-ventral projection of pygophor short and sharp. Anal segment large. Anal style jet-black. Genital styles with stem rather

suddenly bent, apex triangular. Aedeagus straight with two backwardly-directed hooks and a membranous appendage.

♀. Length, 4 mm.; tegmen, 5 mm. Pale brown, eyes dark. Carinae and angles whitish. Tegmina hyaline with whitish veins; tips of veins and apical cross-veins black. Two blackish smudges at nearly half-way, just cephalad of claval suture. Ovipositor stout.

Redescribed from thirteen males and nineteen females. Tarawera (R. J. Tillyard), Herne Bay (W. G. Howes), Auckland (I. H. Myers), Rangitoto Island (I. H. and J. G. Myers)– all in Auckland Province.

Mr. Muir compared my specimens with the type in the British Museum. He writes, "This agrees with the type, which is a male; there is another male and three females in the type series."

Cixius interior Walker. (Plate 20, figs. 5, 6.)

Walker, List Homopt. Insects in *Brit. Mus. Suppl.*, p. 82, 1858. Buchanan White, *Ent. Mo. Mag.*, vol. 15, p. 216, 1879. Hutton, *Trans. N.Z. Inst.*, vol. 30, p. 185, 1898; *Index Faunae Nov. Zeal.*, p. 224, 1904. Kirkaldy, *Trans. N.Z. Inst.*, vol. 41, p. 28, 1909.

Cixius aspilus Walker, List Homopt. Insects in *Brit. Mus. Suppl.*, p. 83, 1858. Buchanan White, *Ent. Mo. Mag.*, vol. 15, p. 216, 1879. Hutton, *Trans. N.Z. Inst.*, vol. 30, p. 186, 1898; *Index Faunae Nov. Zeal.*, p. 225, 1904. Kirkaldy, *Trans. N.Z. Inst.*, vol. 41, p. 28, 1909.

♂. Length, 4 mm.; tegmen, 5 mm. Pale-greenish; veins, carinae, and angles greener. Eyes dark brown. Tegmina hyaline, veins slightly darker and thicker towa.ks tips. Stigma hyaline or whitish. At least two apical cross-veins blackish. A blackish streak on wing-margin at apex of clavus. Frons green, clypeus yellowish-brown. Medio-ventral projection of pygophor prominent. Genital styles somewhat as in preceding species, but not bent so abruptly. Aedeagus more complex, long and straight, with three backward hooks and a membranous appendage all grouped near distal end.

♀. Length, 4 mm.; tegmen, 5 mm. Resembles male generally. Ovipositor very dark and stout.

Redescribed from eight males and six females. Rangitoto Island and Waitakerei Hills, Auckland (I. H. and J. G. Myers). Specimens have since been seen from Wanganui (J. G. M.) and Taumarunui (T. R. Harris).

It is with some doubt that Walker's name is given to this species. Mr. Muir, after examining the types, writes: "The type of *C. interior* is a female and the type of *aspilus* is a male, and they appear to be the same species. They are unicolorous, reddish-yellow, with clear tegmina bearing black macrochetae. This colour may have been originally green and have turned yellowish-red. If so, they appear to be your No. 249."

It is interesting to note in this connection that several of my specimens, none of which are more than sixteen months old, are already turning yellowish. Walker's character, "transverse veinlets forming two lines, the interior one incomplete," is seen in the photograph (Plate 20, fig. 5). Walker gives the colour as "testaceous" or "pale testaceous." This beautiful green species is one of our finest Cixiids. As its colour would lead one to expect, it is more essentially a dweller among the green foliage of shrubs and small trees than are the other species. In habitus, and to a less extent in the appearance of the male genitalia, it affords a transition from *Cixius* to *Koroana*.

Cixius rufifrons Walker.

Walker, List Homopt. Insects in *Brit. Mus. Suppl.*, p. 83, 1858. Buchanan White, *Ent. Mo Mag.*, vol. 15, p. 216, 1879. Hutton, *Trans. N.Z. Inst.*, vol. 30, p. 186, 1898; *Index Faunae Nov. Zeal.*, p. 225, 1904. Kirkaldy, *Trans. N.Z. Inst*, vol. 41, p. 28, 1909.

"Tawny. Head testaceous; vertex narrow, concave; front and face with a distinct keel, their borders slightly elevated; face and disc of the front red. Prothorax very short, much arched. Mesothorax with three keels. Abdomen somewhat luteous. Wings vitreous; veins testaceous, with black points towards the tips; stigma pale testaceous; with a blackish dot. Length of the body, 2 lines; of the wings, 6 lines. (*a*.) New Zealand. Presented by Colonel Bolton." (*Walker*.)

This species is totally unknown to me. From the description I should have expected it to be synonymous with *C. aspilus* (*C. interior*), but Mr. Muir writes as follows: "*C. rufifrons* Walker type is a male very close to *aspilus*, but the genital styles are broader and the anal segment light (in *aspilus* and *interior* it is fuscous)."

Cixius kermadecensis n. sp.

♀. Length, 4·4 mm.; tegmen, 5·5 mm. Pale-brownish, darker on eyes and angles of pronotum and abdomen. Ventral surface pale. Abdomen darker, with whitish edges to segments. Ovipositor strongly curved; extending slightly beyond tip of abdomen. Frons and clypeus unicolorous, pale drab, edges of face raised. Tegmina hyaline, veins pale brown, macrotrichia darker and very conspicuous. A broad brown transverse smudge at one-third of tegmen, and a smaller one at apex of clavus. Stigma with brownish centre edged with white. Hind-border of vertex less roundly notched than in most other Cixiids, also line bounding vertex cephalad, more angulate.

Described from one female. Sunday Island, Kermadec Islands, 1908 (W. L. Wallace, No. 4); on kawakawa (*Macropiper excelsum*).

Holotype in Dominion Museum, Wellington. I am indebted to the Dominion Museum authorities for the opportunity of describing this insular species.

Genus 2. KOROANA nov.

Type: *K. helena* n. sp.

Longitudinal carina of vertex extremely obscure or entirely obsolete. Clypeus fairly rounded, without median longitudinal carina (Plate 21, fig. 6). Male genitalia complex; three very twisted hooks at base of membranous distal part of aedeagus. Tegmina long and narrow, subparallel-sided. Sc and R joined until half the length of the tegmen; their bases joined to M near base of tegmen. Forking of C about two-thirds along clavus. Claval veins joining margin considerably before apex of clavus, forking about middle. Cu usually touching M for some distance.

In other respects resembles *Cixius*. The venation exhibits considerable variation, as shown by the illustrations (Plate 21, figs. 1-5; Plate 22, figs. 1-3). Of the two species, one is apparently confined to the North Island and the other to the South.

Koroana helena n. sp. (Plate 21, figs. 1–8.)

♂. Length, 4 mm.; tegmen, 5 mm. Reddish, relieved with black. Vertex brownish, eyes dark. Pronotum pale-yellowish. Mesonotum henna-colour, the lateral carinae black, the median greenish. Apex of scutellum

greenish, metanotum black. Basal two or three abdominal segments black; remainder pale-reddish. Frons yellowish, with an area on each side of median ridge and whole of clypeus reddish—distinctly delimited. Tibiae usually with black proximal and distal bands. Tegmina hyaline. Veins brownish, darker at tips, with distinct black macrotrichia. An interrupted, more or less double and very variable brownish fascia obliquely transverse at a little past a third (sometimes practically obsolete). Stigma fuscous, margined with whitish. Genitalia fuscous. Medio-ventral projection of pygophor prominent. Genital styles with the blade bent sharply at right angles to stalk. Apex of peculiar shape, as shown in Plate 21, figs. 7, 8. Aedeagus with three hooks at base of membranous portion, two of the hooks twisted together in a characteristic manner (Plate 21, figs. 7, 8).

♀. Length, 4·8 mm; tegmen, 5·4 mm. Less brightly coloured than male. Disc of mesonotum between lateral carinae entirely greenish. Distal half of abdomen with indications of a median black longitudinal mark. Ovipositor pale-brownish, long and slender.

Described from fifty-three males and thirty-nine females. Apparently throughout North Island.

Holotype and allotype: Myers collection, Department of Agriculture.

This is essentially a bush-, shrub-, and tree-frequenting species.

Koroana arthuria n. sp. (Plate 22, figs. 1–4.)

♂. Length, 4 mm.; tegmen, 4·6 mm. Close to the preceding species, but distinguished by the stouter and more depressed form, shorter tegmina, and darker colour and more abundant pruinosity on both sexes, and also by the following characters: Tegmen with a semicircular fuscous patch on fore-border between one-third and half-way. This is always present, even in the paler forms, and furnishes a means of distinction at first glance. Hooks of aedeagus less twisted, and other genital differences as shown in Plate 22, fig. 4.

♀. Length, 4·5 mm.; tegmen, 4·9 mm. Colour paler than that of male. Ventral surface of abdomen black.

Described from twenty-two males and fifteen females. Trio Islands, Cook Strait (R. J. Tillyard); Mount Arthur (A. Philpott); Arthur's Pass (R. J. Tillyard, J. W. Campbell, W. G. Howes, I. H. and J. G. Myers) Waitati, Otago (C. E Clarke); Queenstown (W. G. Howes).

These are all South Island localities. The Trio Islands form is consistently smaller and lighter in colour than the type (Arthur's Pass), but I can find no structural differences.

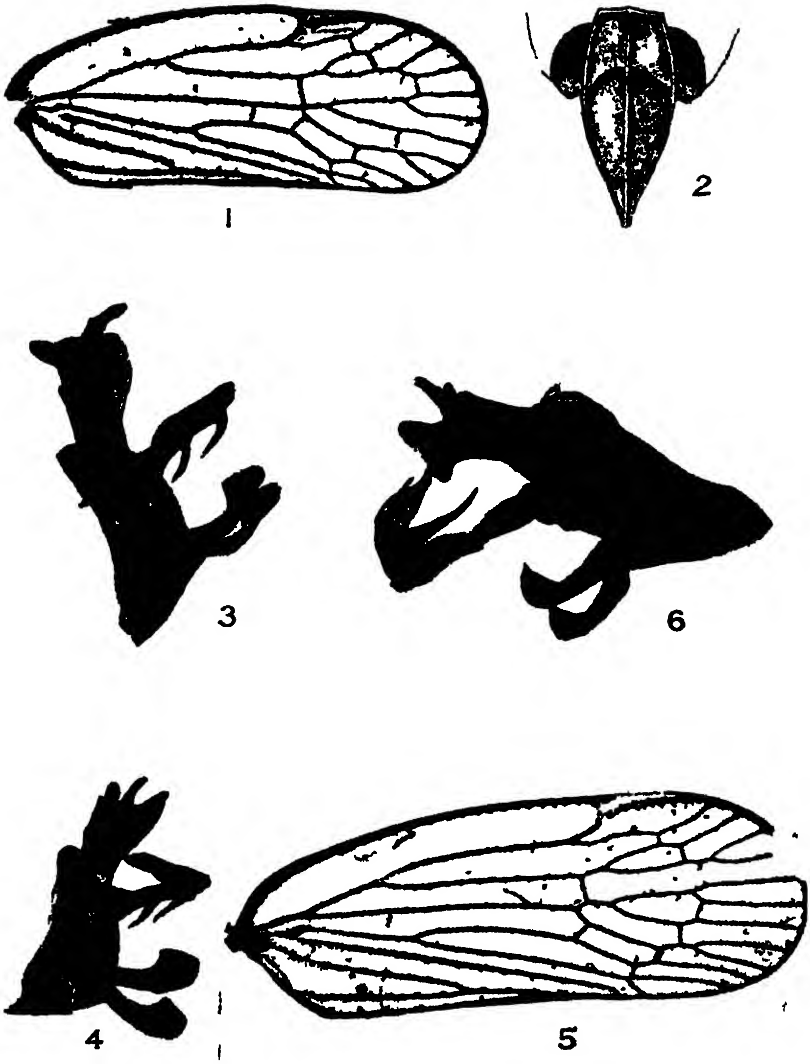
Holotype and allotype: Myers collection, Department of Agriculture.

This species was reared in large numbers from nymphs beneath stones at Arthur's Pass. Small ants were also present, but myrmecophily was not definitely established.

Genus 3. Semo Buchanan White.

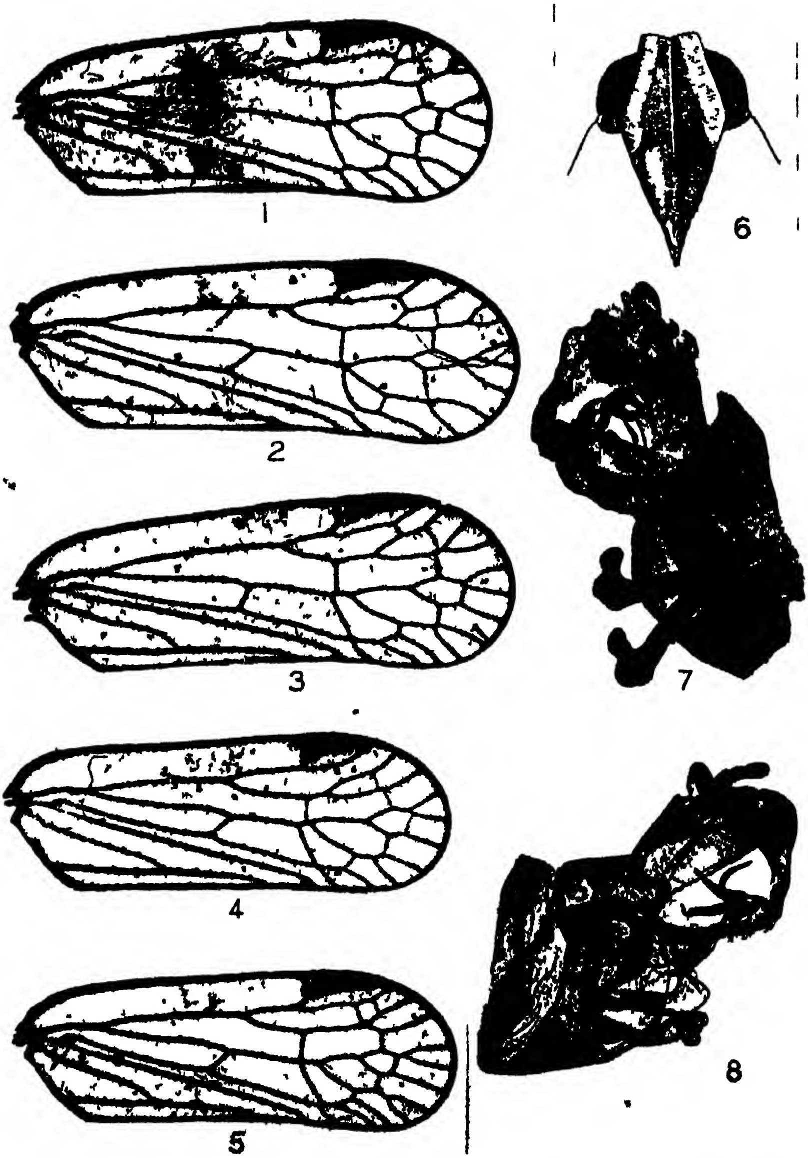
Type: *S. clypeatus* Buchanan White.

Buchanan White's description is good, except that the head, including eyes, is not as wide as pronotum. There is, therefore, no need to redescribe the genus, especially as its salient distinguishing features are incorporated in the generic key. The male genitalia approach those of the New Zealand species of *Cixius*, but are very much less armed.



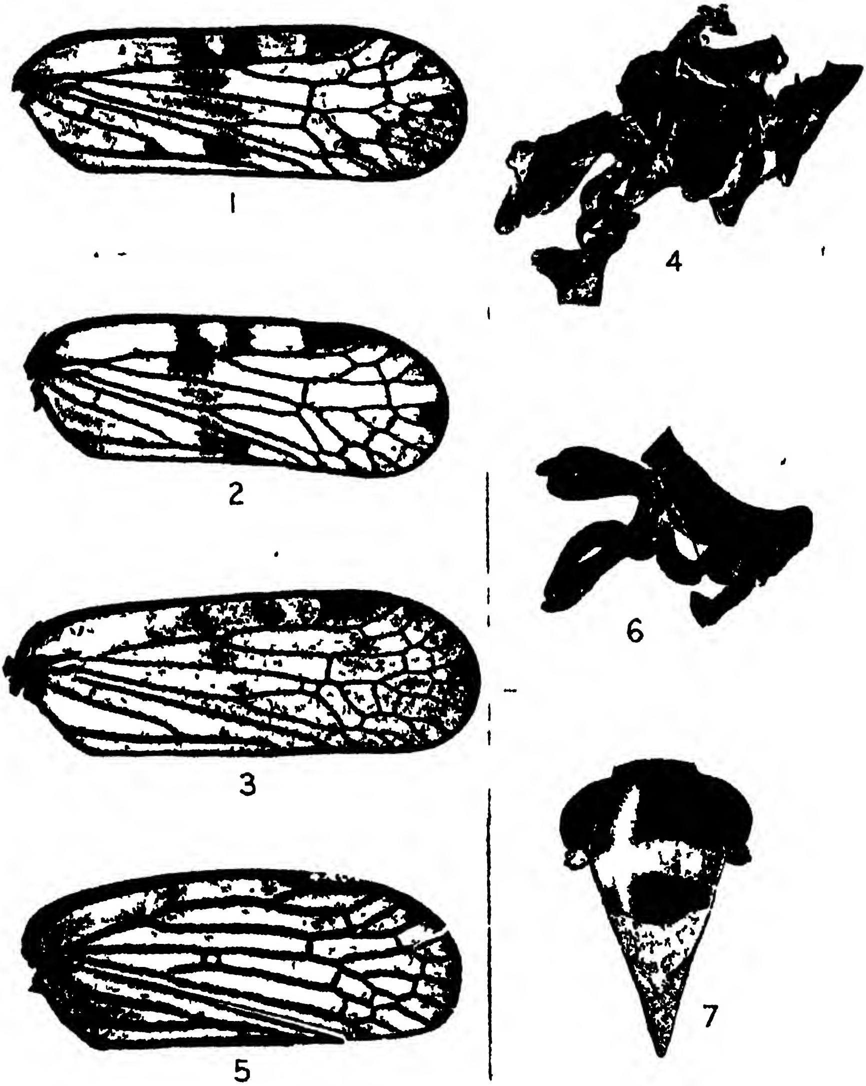
[B. D. Reid photo and J. H. Atkinson sketch]

FIG. 1.—*Cixius punctimargo* Walker: right tegmen.
FIG. 2.—*Cixius punctimargo* Walker: face.
FIG. 3.—*Cixius punctimargo* Walker: male genitalia, lateral view.
FIG. 4.—*Cixius punctimargo* Walker: male genitalia, semi-lateral view.
FIG. 5.—*Cixius interior* Walker: right tegmen.
FIG. 6.—*Cixius interior* Walker: male genitalia, lateral view.



B. D. Reid, photo. and J. H. Atkinson, sketch.

Figs. 1–5.—*Koroana helena* n. sp.: right tegmen of specimens from various localities showing venational variation.
Fig. 6.—*Koroana helena*: face.
Figs. 7, 8.—*Koroana helena*: male genitalia, views from different aspects of two different specimens.



[H. D. Reid, photo., and E. H. Atkinson, del.

Figs. 1, 2.—*Koroana arthuria* n. sp.: right tegmen of two specimens of typical form from Arthur's Pass.
Fig. 3.—*Koroana arthuria*: right tegmen of form from Trio Island.
Fig. 4.—*Koroana arthuria*: male genitalia, lateral view, typical form from Arthur's Pass (the Trio Islands form does not differ in genitalia).
Fig. 5.—*Semo clypeatus* Buchanan White: right tegmen.
Fig. 6.—*Semo clypeatus* Buchanan White: male genitalia, lateral view.
Fig. 7.—*Huttia nigrifrons* n. gen. et sp.: face (flagella of antennae broken).

Semo clypeatus Buchanan White. (Plate 22, figs. 5, 6.)

Buchanan White, *Ent. Mo. Mag.*, vol. 15, p. 217, 1879; Hutton, *Trans. N.Z. Inst.*, vol. 30, p. 187, 1898; *Index Faunae Nov. Zeal.*, p. 225, 1904. Kirkaldy,* *Trans. N.Z. Inst.*, vol. 41, p. 29, 1909.

♂. Length, 3·5 mm.; tegmen, 4 mm. "Pale ochreous-brown. Head (except the keels of the vertex, side of the frons and antennae), scutellum (except the side margins), apex of tarsi and abdomen (except genitalia) more or less piceous or piceous-black" (*Buchanan White*). To this may be added the following description of genitalia: Pale-brownish. Medio-ventral projection of pygophor prominent but wide and rounded. Genital styles with very short stalks and long blades with broad roundish base and narrower apex. Aedeagus straight and almost unarmed.

♀. Length, 4 mm.; tegmen, 4·5 mm. Colour slightly paler. Ovipositor brownish, stout, but sharply pointed. Normally a heavy mass of waxy material between anal segment and ovipositor.

Twenty-five males and thirty-five females. Mount Egmont (Miss J. Anson); Tararua Ranges, 3,300–3,600 ft. (J. G. Myers); Mount Arthur (T. Cockcroft); Arthur's Pass, 2,600–2,800 ft. (I. H. and J. G. Myers); Wakatipu, 3,600 ft. (G. V. Hudson). Hutton gives the range as "Otago."

This short squat species is apparently confined to the subalpine scrub and to the undergrowth of the forest at its upper limit, in which places it often occurs in vast numbers. The South Island specimens have tegmina slightly more variegated—some of the veins being more conspicuously picked out in whitish than in the North Island specimens—but this difference is not constant.

Genus 4. HUTTIA nov.

Type: *H. nigrifrons* n. sp.

Body short and squat. Tegmina long and hyaline. Vertex with a median longitudinal ridge. Face with no median longitudinal carina. Pronotum very narrow, flattish, with a median longitudinal keel and two lateral ones, none very prominent. Mesonotum rounded, with five keels. Hind tibiae spined. Tegmina long, narrow and parallel-sided. Sc and R joined for rather less than one-third; their bases joined to M for about one-eighth of clavus. Cu forked about middle of clavus; claval veins joining margin near apex, forked about middle. A cross-vein from first claval to Cu_2 at about one-fifth along clavus.

Huttia nigrifrons n. sp. (Plate 22, fig. 7.)

♀. Length, 5 mm.; tegmen, 6·5 mm. Olivaceous marked with blackish. Disc of vertex and of pronotum blackish. Inner two keels of mesonotum curved so that their ends almost touch median keel; all three very distinct, the keels olivaceous and intervening spaces blackish. Tegmina glassy-clear, including the veins, except where the latter, at intervals, are marked with black. A few fuscous marks along the inner border of clavus. Abdomen rounded. Anal segment and ovipositor almost same length, both black and slender. Legs long. Frons almost entirely shining-black; a wide transverse band of white at fronto-clypeal suture, followed by a transverse nearly semicircular band of shining-black; rest of clypeus pale-brownish.

* I do not understand why Kirkaldy placed this, together with *Aka* and the Achilid *Agandecca*, in his Poekillopteridae.

One female. Pakuratahi, Upper Hutt, Wellington (T. Cockcroft). I am deeply indebted to Mr. T. Cockcroft for his sole specimen of this interesting species.

Holotype, female: Myers collection, Department of Agriculture.

Huttia harrisi n. sp.

♀. Length, 5 mm.; tegmen, 5·5 mm. Olivaceous, pronotum green. Inner two keels of mesonotum only faintly indicated. Keels paler in colour than disc. Tegmina hyaline, veins fuscous; stigma whitish. Four fuscous marks on fore-border of tegmen; apical cells tipped with fuscous; a blackish smudge just beyond apex of clavus. Ovipositor brownish, shorter in proportion to its width than in previous species. Frons greenish, passing into yellowish on the clypeus, which is faintly obliquely ridged.

One female. West coast, South Island (T. R. Harris). I have much pleasure in dedicating this fine species to the discoverer.

Holotype: Myers collection, Department of Agriculture.

The localities from which the two species of *Huttia* have come, one in North Island and one in South, are both heavily forested.

Genus 5. Malpha nov.

Type: *M. muiri* n. sp.

Body short and stout and somewhat depressed. Tegmina short and oblong. Division of Sc and R before half-way from base to stigma, their bases joined to M only up to less than a quarter of clavus. Forking of Cu a little more than half-way from base of clavus. Claval veins joining margin well before apex; forking beyond middle. Carina at apex of vertex and base of face obscure or missing; median frontal carina forked about middle of face (in this character approaches *Aka*). Vertex slightly wider than long; widest at base, which is emarginate in a broadly wedge-shaped manner; lateral carinae well developed, continuing unbroken on to the face. Clypeus with median carina fairly distinct; lateral carinae (raised edges) less so. Antennae fairly long; first segment very short; second longer than wide. Prothorax short; hind-margin excavated by a right angle; a median longitudinal carina. Mesonotum with five carinae; distinctly flattened between carinae; hind-margin forming an equilateral triangle. Female with ovipositor short. Hind tibiae spined.

Malpha muiri n. sp. (Plate 23, figs. 1, 2.)

♂. Length, 4 mm.; tegmen, 4·3 mm. Olivaceous marked with chocolate-brown. Lateral margin of pronotum, sides of mesonotum, part of metanotum, and base of abdomen rich chocolate-brown. Frons widest at two-thirds from base, where the sides are strongly raised, basal portion pale-greenish, followed by a wide band of shining-piceous, next a band of yellowish, along the middle of which the fronto-clypeal suture shows as a fine reddish hair-line; apical half of clypeus shining-piceous. Fore and middle tibiae with a proximal and a distal ring of brownish; rest of legs pale. Tegmina clouded with yellowish-white; veins fuscous at intervals except on apical half where they are continuously dark. Stigma yellowish, three or four indistinct marks along costa, and another at distal end of claval vein. Wings milky, veins black. Genital styles small, apical portion of blade narrowed into a small, finger-like process. Aedeagus complex.

♀. Length, 4 mm.; tegmen, 4·3 mm. Colours and markings more obscure. Ovipositor very short and stout but projecting beyond anal segment; between them a small wax-secreting area.

One male and one female. Mount Alpha, 3,600 ft., Tararua Range; on undergrowth of shrubby *Senecio* and *Olearia* in *Nothofagus* forest (J. G. Myers).

Holotype and allotype: Myers collection, Department of Agriculture.

I dedicate this, the genotype of an endemic genus, to Mr. F. Muir.

Malpha iris n. sp.

♀. Length, 4 mm.; tegmen, 4·6 mm. In dorsal view, second joint of antennae projecting well beyond eyes. Pale-brownish; the tegmina folded almost horizontally; glassy-clear with veins fuscous, in parts white. Stigma whitish; apically somewhat thickened and blackish. A black spot at the lateral corners of mesonotum. Basal portion of frons whitish; borders shining yellowish-brown; apical part shining-piceous except to within a short distance of clypeus. Median ocellus black (at least there is a black dot in this position. I am not sure whether it is a functional ocellus). Clypeus long and narrow, whitish. *There is a distinctly marked line of colour from the base of the tegmen on one side to that on the other, passing across face just cephalad of the fronto-clypeal suture: all cephalad of this line, except the basal part of the frons, is shining-black; all caudad of the line is dull-white*—a most striking demarcation. Ovipositor short and stout.

One female. York Bay, Wellington; mixed *Nothofagus* and rain forest (I. H. Myers). I dedicate this species to the discoverer, my wife.

Holotype, female: Myers collection, Department of Agriculture.

Malpha duniana n. sp. (Plate 23, fig. 3.)

♂. Length, 4 mm.; tegmen, 4·1 mm. Olivaceous marked with fuscous. Abdomen blackish. Frons olivaceous spotted with fuscous; fronto-clypeal suture strongly depressed, marked with greenish-white. Mesonotum with the two inner keels somewhat obscure. *Bases of wings and of tegmina milky-white marked with black.* Tegmina hyaline with a fuscous area near the base covering more than half of clavus; a brownish splash including the distal portion of stigma and extending obliquely on to the disc; another at apex of hind (inner) margin of tegmen. Veins blackish and white alternately; extreme tips blackish and thickened. Three or four blackish marks along costa. Wings short and broad. Genital styles large and spatulate. Aedeagus complex, resembling that of *M. muiri.* Fore and middle legs with a proximal and a distal band of brownish.

♀. Length, 5 mm.; tegmen, 5·1 mm. The two inner keels of mesonotum almost obsolete. Abdomen dark. Ovipositor somewhat larger than that of *M. muiri* and *M. iris.*

One male and two females. Dun Mountain, Nelson, 3,000 ft. (R. J. Tillyard and A. Philpott).

Holotype: Myers collection, Department of Agriculture. Allotype: Cawthron Institute.

In the structure of the face and in the shape of the genital styles this species approaches *Aka* more than do the other species of the genus.

Malpha cockcrofti n. sp.

♀. Length, 4·5 mm.; tegmen, 5 mm. Uniform reddish-ochraceous, deepening on the face, under-parts, and mesonotum to a shining-tawny.

Eyes dark. Frons with strong lateral carinae, the fork of median carina very distinct; fronto-clypeal suture almost straight. Face concolorous. Mesonotum concolorous, the inner carinae pale. Tegmina hyaline suffused with orange, veins alternately fuscous and white. Ovipositor not quite so short and stout as in the three preceding species. A large mass of waxy material between ovipositor and anal segment.

One female. Otira, South Island; subalpine (T. Cockcroft).

Holotype: Myers collection, Department of Agriculture.

I have much pleasure in naming this species after its discoverer, to whom I am indebted for much valuable material.

Genus 6. OLIARUS Stal.

Type: *O. walkeri* (Stal.).

This cosmopolitan genus is sufficiently differentiated by the characters included in the foregoing generic key. The five mesonotal carinae are usually very strongly marked. The male genitalia of the New Zealand forms show peculiar battle-axe-shaped genital styles and a complex aedeagus with some of the sharp processes projecting almost directly caudad instead of being recurved.

Oliarus oppositus (Walker). (Plate 23, figs. 1–7.)

Cixius oppositus Walker, List Homopt. Insects in *Brit. Mus. Suppl.*, p. 345 46, 1850.

Oliarus oppositus (Walker) Buchanan White, *Ent. Mo. Mag.*, vol. 15, p. 217, 1879. Hutton, *Trans. N.Z. Inst.*, vol., 30, p. 186, 1898; *Index Faunae Nov. Zeal.*, p. 225, 1904. Kirkaldy, *Trans. N.Z. Inst.*, vol. 41, p. 29, 1909.

Cixius marginalis Walker, *ibid.*, Suppl., p. 82, 1909.

Oliarus marginalis (Walker) Buchanan White, *Ent. Mo. Mag.*, vol. 15, p. 216, 1879. Hutton, *Trans. N.Z. Inst.*, vol. 30, p. 186, 1898; *Index Faunae Nov. Zeal.*, p. 225, 1904. Kirkaldy, *Trans. N.Z. Inst.*, vol. 41, p. 29, 1909. Hudson, *Trans. N.Z. Inst.*, vol. 54, p. 343, 1923.

♂. Length, 3·5 mm.; tegmen, 4·7 mm. Jet-black, with parts of eyes, the edges of pronotum, of tegulae, and of vertex, carinae of face, proximal half of labium, joints of legs, and a very narrow edging to abdominal segments tawny. Carinae of mesonotum black and concolorous with disc. Tegmina hyaline faintly suffused with greyish-yellow. Veins yellowish; black at tips; apical cross-veins black. Macrotrichia black and conspicuous. Stigma whitish, edged behind and distally with blackish. Genital styles with a conspicuous notch in the stem; apical portion halberd-shaped. Aedeagus very complex.

♀. Length, 3·5 mm.; tegmen, 4·7 mm. Ovipositor extremely short. A large mass of waxy material between it and anal segment. Possibly the average size of the female is slightly larger than that of the male. My largest specimen is a female, and my smallest a male.

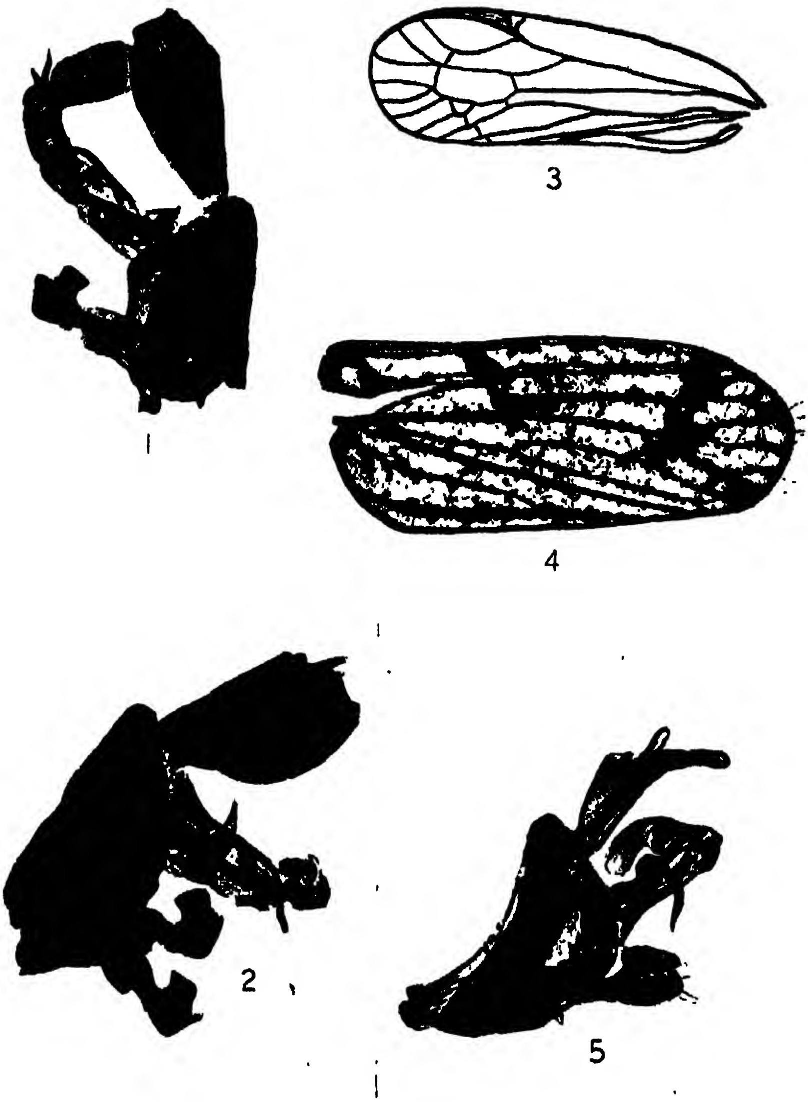
Redescribed from thirty-five males and fifty-four females. Widespread over both Islands, and to an elevation of at least 4,500 ft. [Tararua Range (J. G. Myers)]. This species frequents grass and ground herbage. The size is variable, and Walker's *marginalis* was apparently described from rather larger specimens. My smallest specimen is only 2·9 mm. in length.

Dr. R. J. Tillyard collected a small form on Stephen Island and the Trio Islands in Cook Strait. This is consistently smaller than the mainland form, but I can find no other differences.

W. D. Reid, photo.

Fig. 1.—*Malpha muiri* n. gen. et sp.: right tegmen.
Fig. 2.—*Malpha muiri* n. gen. et sp.: male genitalia, lateral view.
Fig. 3.—*Malpha dunnana* n. sp.: male genitalia, lateral view.
Figs. 4, 5. *Oliarus oppositus* (Walker): male genitalia, lateral view, two typical specimens, from Aramoho and Whangarei respectively.
Fig. 6.—*Oliarus oppositus* (Walker): male genitalia, lateral view; Stephen Island specimens.
Fig. 7.—*Oliarus oppositus* (Walker: male genitalia, lateral view; Arthur's Pass specimen.

Face p. 324.]



[*W. D. Reid, photo.*

FIGS. 1, 2.—*Oliarus atkinsoni* n. sp.: male genitalia; views of two specimens. In fig. 1 one genital style has been broken off.
FIG. 3.—*Tiritea clarkeiana* n. gen. et sp.: left tegmen. (Drawing, J. G. M.)
FIG. 4.—*Aka finitima* (Walker): right tegmen.
FIG. 5.—*Aka finitima* (Walker): male genitalia, lateral view.

There is a very dark form at Arthur's Pass (subalpime to alpine) in which the veins and stigma are almost entirely black. I can detect no differences in structure. This form was reared from nymphs beneath stones.

Oliarus atkinsoni n. sp. (Plate 24, figs. 1, 2.)

♂. Length, 5 mm.; tegmen, 6·3 mm. Close to the preceding species, but differing in its very much greater size and in the following particulars: *Whole body* dusted with pruinose material so that to the naked eye it appears greyish. Tegmina colourless but clouded with whitish. Macrotrichia inconspicuous. Stigma white proximally, black distally. Genitalia differing as shown in the illustration (Plate 24, figs. 1, 2). The stem of the genitalia-styles is more deeply notched and the blade larger in proportion.

♀. Length, 5·8 mm.; tegmen, 7·5 mm. A mass of flocculent, fibrous, waxy material, often as large as abdomen, projecting a considerable way behind anal segment and ovipositor, which latter resembles that of the preceding species.

Described from fourteen males and twenty-six females. Waikanae (E. H. Atkinson); Wellington (J. G. Myers). In considerable numbers on the under-sides of the leaves of New Zealand flax (*Phormium tenax*).

This large and sluggish species has gone a step further than *Oliarus oppositus* in its preference for ground herbage as distinct from bushes, and is found only in flax-swamps, apparently attached to the flax itself, where it may be found sitting singly or *in copula* on the shaded side of the leaf.

It is with much pleasure that I dedicate this species to the discoverer Mr. E. H. Atkinson.

Genus 7. TIRITEANA nov.

Type: *T. clarkei* n. sp.

Tegmina comparatively narrow, parallel-sided, rounded at apex. Margins with distinct border all round, widening out at stigma. Sc and R joined to about half length of tegmen; their bases joined to M for only a very short distance from base. Forking of Cu just basad of separation of Sc and R. Claval vein joining margin before apex, forking rather distad of half length of clavus.

Longitudinal carina of vertex very short, not forked; median frontal carina nor forked. Hind-margin of vertex very broadly and roundly emarginate. Second joint of antennae nearly twice as long as thick. Base of face about half width of apex. Pronotum very short, with median longitudinal keel. Mesonotum long and narrow, tricarinate, somewhat flattened between carinae; hind-margin forming acute angle. Posterior tibiae unarmed. Ovipositor rather short and stout. Flocculent waxy material secreted caudally.

Tiriteana clarkei n. sp. (Plate 24, fig. 3.)

♀. Length, 3·8 mm.; tegmen, 4·9 mm. Dark chocolate-brown: vertex and pronotum paler. Frons widest at about two-thirds from base, where the sides are strongly elevated; shining dark-brown. Clypeus whitish. Under-surface and legs whitish, except abdomen, claws, and distal coronets of tibiae, which are all dark. Antennae long and dead-black. Eyes dark. Pronotum posteriorly broadly angularly emarginate. Mesonotal carinae narrow but very distinct. Tegmina hyaline suffused intermittently with yellowish. A smoky cloud extending from apex of fore-border to apex of clavus obliquely; clavus mostly yellowish; a fuscous cloud at base of

corium. Veins brownish; macrotrichia darker. Wings hyaline, smoky; veins fuscous. Ovipositor stout. Flocculent material in form of long silky fibres.

Two females. Mamaku (C. E. Clarke); Tiritea, Palmerston North (R. J. Tillyard). Dr. Tillyard's specimen was taken in undergrowth of rain forest.

I have much pleasure in dedicating this, the type of a curious endemic genus, to its discoverer, Mr. C. E. Clarke, to whom I am already indebted for much interesting material.

Genus 8. AKA Buchanan White.

Type: *A. finitima* (Walker).

This very distinct genus is sufficiently differentiated by the characters given in the generic key. The tegmina are short and curved to fit the body. The hind legs are extremely long. The male genitalia of the genotype are described below.

Aka finitima Walker. (Plate 24, figs. 4, 5.)

Cixius finitimus Walker, List Homopt. Insects in *Brit. Mus. Suppl.*, p. 81, 1858.

Aka finitima (Walker): Buchanan White, *Ent. Mo. Mag.*, vol. 15, p. 216, 1879. Hutton, *Trans. N.Z. Inst.*, vol. 30, p. 186, 1898; *Index Faunae Nov. Zeal.*, p. 225, 1904. Kirkaldy, *Trans. N.Z. Inst.*, vol. 41, p. 29, 1909.

♂. Length, 4 mm.; tegmen, 3·5 mm. Pale-brownish, heavily spotted and blotched with fuscous; a forked median longitudinal carina on vertex. Side keels and one median longitudinal keel on pronotum. Mesonotum with three strongly-marked carinae and indications of two more; finely transversely striate; outermost carinae bow-shaped, their concavity towards the centre. Tegmina hyaline; veins fuscous and whitish in alternate stretches; six fuscous spots on fore-border; a paler brownish clouded area at base, on centre of disc, and near apex; a distinct fuscous spot just beyond apex of clavus—in some specimens this fuscous spot is enlarged to form a great dark splash across apex of tegmen. Wings hyaline; veins almost colourless. Abdomen almost black. Genitalia fuscous. Genital styles straight-stalked, large-bladed, spatulate. Aedeagus complex, stout; three much-curved hooks at base of membranous appendage.

♀. Length, 5 mm.; tegmen, 4·3 mm. Ovipositor large and sabre-shaped, extending well beyond abdomen. Anal segment small. *No pruinosity.*

Redescribed from thirty-four males and twenty-nine females. Frequents lowland rain-forest, but is particularly numerous in subalpine scrub from 3,500 ft. to 4,000 ft. Tararua Range (J. G. Myers). The tegminal pattern is extremely variable. In July a freshly-emerged adult was found in leaf-mould, showing that the nymphal stadia are probably passed in a cryptozoic habitat.

Wellington district (G. V. Hudson, T. Cockcroft, J. G. Myers); Tararua Range (J. G. Myers); Canterbury (Hutton): Leith, Dunedin (W. G. Howes).

Mr. G. V. Hudson has given me a large handsomely marked female with the following dimensions: length, 6·3 mm.; tegmen, 5·9 mm. This is gigantic; but intermediates are not lacking, and I am loth to separate it specifically until males are discovered and dissected.

The Leaf-mining Insects of New Zealand: Part 4—Charixena iridoxa *Meyr.*, Apatetris melanombra *Meyr.*, Philocryptica polypodii *Watt (Lepidoptera).*

By MORRIS N. WATT, F.E.S.

[*Read before the Wanganui Philosophical Society, 28th October, 1921; received by the Editor, 31st December, 1922; issued separately, 8th July, 1924.*]

Plates 25–31.

(24.) Charixena iridoxa Meyr. (The Astelia-moth). (Plates 25, 26, and Plate 31, figs. 1–3.)

Philpottia iridoxa Meyr., *Trans. N.Z. Inst.*, vol. 48, p. 417, 1916.
Genus *Charixena* Meyr., *Trans. N.Z. Inst.*, vol. 53, p. 335, 1921.

This, one of the most beautiful and striking of the endemic moths, has an extremely interesting life-history, and amongst leaf-mining insects its mine is the largest, the most conspicuous, and most interesting of all. Owing to its being subalpine I have had no opportunity for a continuous study of its habits, the present paper being the result of some five or six short visits to Mounts Egmont and Ruapehu, spread over the same number of years. Although the following notes are therefore far from complete, their publication may be a useful guide to any one wishing to study this moth in its native habitat. Although the mine and the larval and pupal forms were long known, it was not until recently that the imago was successfully reared and the identity of the insect established.

The curious large zigzag tracks on the leaves of the *Astelia* first attracted my attention in 1914, but it was not till Christmas, 1918, that I was able to give them further attention in the same locality, Mount Egmont. The zigzag markings on the leaves widened as they descended, and eventually disappeared into the heart of the plant; and on digging up a plant and separating the leaves around the bulb a white spindle-shaped dipterous-like larva was discovered. A number of larvae were found, but, my holiday coming to an end, my observations had to be left at this stage. Again in February, 1920, I succeeded in finding several of the curious cocoons containing pupae, which I later took home to Wanganui, and managed to keep them alive for several months, until I tried forcing them by means of gentle artificial warmth, when all dried up and died.

In January, 1922, on Mount Ruapehu, some thirty or forty plants containing the immature stages of the insect were secured, taken to Wanganui, and replanted. Having to go to Dunedin in March, I dug up some of the plants and took them with me, carefully potting them. In June I returned to Wanganui on a short visit, and before leaving Dunedin handed the plants to the care of Mr. C. E. Clarke, and took several more plants down when I returned. The plants all stood this repeated digging up and replanting. One day in early August, considering it time to place a cover

over the plants, I opened one of the cocoons, and what I found made me hastily open the rest: the worst had happened—all had recently emerged and flown. Less than an hour later I visited Mr. Clarke, and on our inspecting the plants I had given him, there, resting on one of the leaves just above its cocoon, was a splendid specimen of *C. iridoxa*. The other three in Mr. Clarke's care emerged during the next few days. What was considered to be a rare moth proves to be plentiful and widespread, its emergence in the very early spring being the secret of its supposed scarcity, since almost all alpine collecting in New Zealand has been done in mid-summer.

The Imago.

A most beautiful moth, metallic purple-bronze with pale lemon-yellow markings.

Meyrick's Original Description.—See *Trans. N.Z. Inst.*, vol. 48, p. 417, 1916.

Distribution.

First taken on Mount Burns, Hunter Mountains, 3,250 ft., on 29th December, 1914, by Mr. Philpott. I think the imago was not again seen till Mr. Clarke and myself reared it as noted above The moth is, however, a common one, its mines being very numerous on Mounts Egmont and Ruapehu; Mr. Clarke has found them plentiful on many of the mountains of Otago; Mr. Philpott records them as common on the Mount Arthur track at 4,000 ft.; and Mr. Fenwick has sent me specimens and records them numerous on the Milford track.

Food-plant.

Astelia montana (alpine bush-flax).

The Ovum and Egg-laying.

Nothing known.

The Larva. (Plate 26, fig. 1.)

A full-grown larva is 21 mm. or more in length, cylindrical, spindle-shaped its greatest diameter about 3 mm. at the third abdominal segment, thence much attenuated towards either end. To the naked eye it is apparently without legs, these being very small, and it is very sluggish in its movements when exposed. The segments are shallowly incised, excepting the seventh and eighth abdominals. Spiracles small, brown, circular. Head small, flattened, light brown. General body-colour transparent shiny white. Tubercles and setae minute and very inconspicuous. Owing to the want of material of known age, no setal charts and head-structure are given at present. The larva throughout its whole life mines within the bulb of the plant below the ground-surface. The duration of the larval existence, the number of moults and their respective periods. are unknown, though from the length of the mines and age of the leaves containing them one may conclude that the larval stage occupies two, if not more, seasons.

The Mine. (Plate 25.)

Commencing in the region of the tip of the leaf, the gallery, at first about $\frac{1}{2}$ mm. in width, gradually assumes its markedly zigzag character,

Mines of *C. iridoxa* in leaves of *Astelia montana*. (About natural size.)

Face p. 328.]

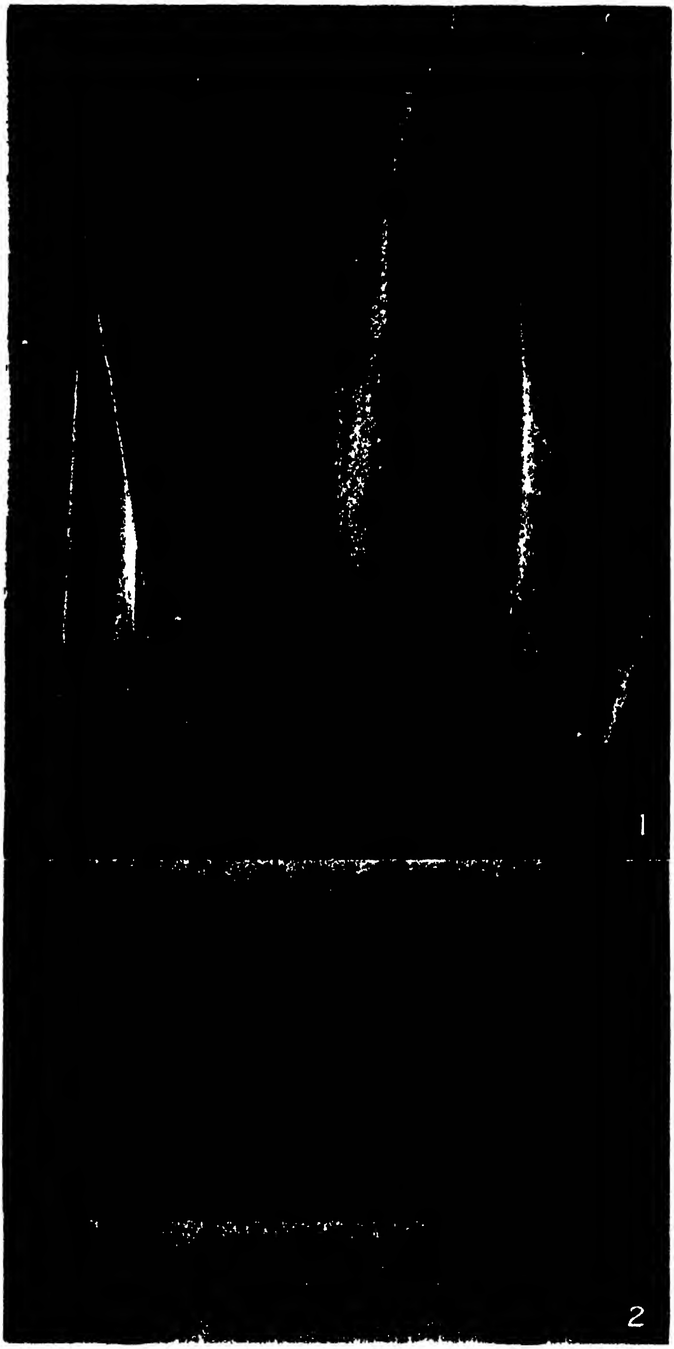


FIG. 1.—Full-grown larva of *C. iridoxa* exposed, just prior to last moult before constructing cocoon. (Enlarged about 1⅔; the dotted line indicates the track of the larva.)
FIG. 2.—Cocoon of *C. iridoxa*. (Slightly enlarged, showing transverse line.)

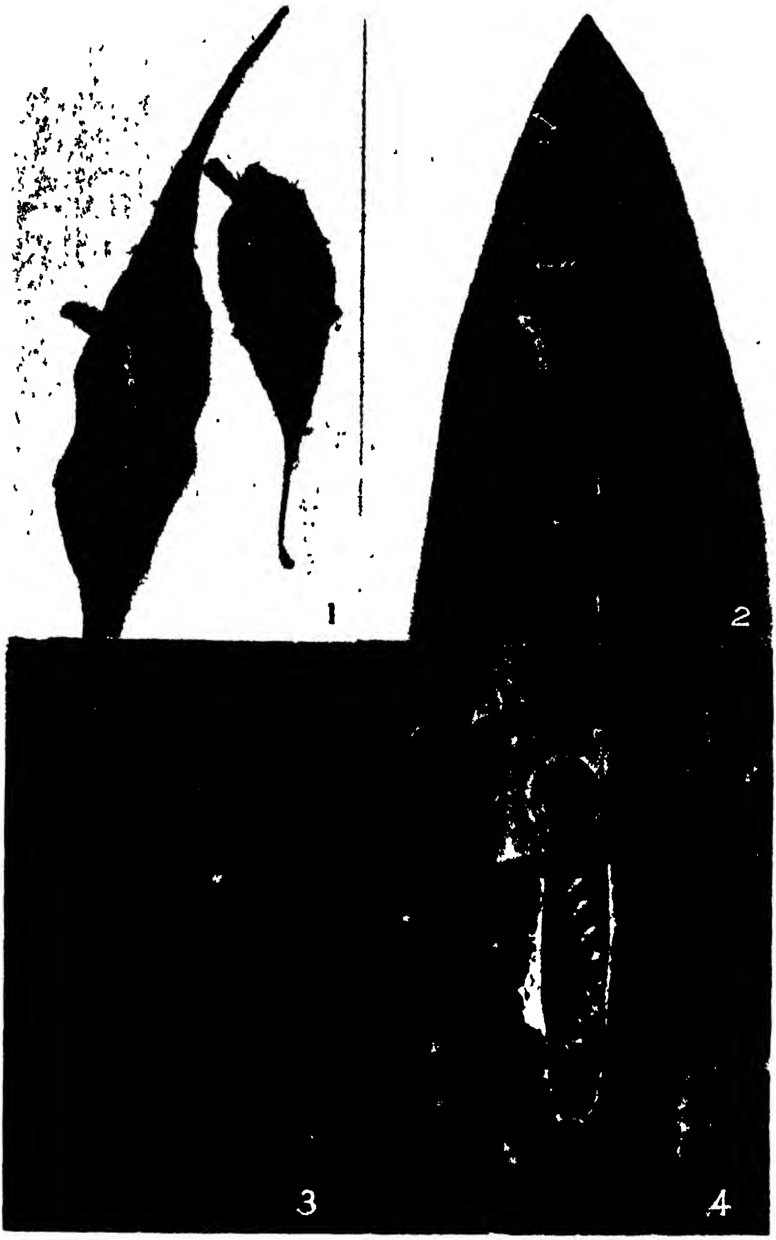


Fig. 1.—Leaves of *Polypodium serpens*, one with the upper cuticle in part removed to disclose the cocoon of *P. polypodii*, showing dehiscence. (About natural size.)

Fig. 2. Mine of *A. melanombra* in leaf of *Celmisia*; photo by direct contact with negative and transmitted light. × = position of first moult; ` · = position of second moult; the third arrow points to the cocoon. (About natural size.)

Fig. 3.—Trap-door of cocoon of *A. melanombra* in a *Celmisia* leaf. (× about 10.)

Fig. 4. The same, with portion of the cuticle of the leaf and roof of cocoon removed, showing larva and cocoon. Note the frass attached to the sides of the cocoon. (× about 10.)

proceeding downwards between the midrib and the outer margin of the leaf; it never crosses the former barrier. As the mine descends, the angles of the zigzag increase in size. All mining is carried on in the bulb of the plant at or just below the surface of the ground and as the leaves grow the gallery is stretched and elongated, and mostly loses resemblance to a typical mine, since the extremely thin outer cuticle is torn and in most places lost, excepting in the most recent portion of the gallery. The zigzag formation of the mine is necessitated by the situation of the larva in the bulb, and its extent is dependent on the rate of leaf-growth: during fast growth the successive angles will be large, while slow growth will cause the transverse portions of the gallery to be almost parallel to one another. Occasionally one will find a length of mine fairly straight for an inch or so, parallel to the long axis of the leaf and most usually close against the midrib; the reason for this may be found on careful search of this portion of the gallery a cast skin adhering to the wall shows that a moult has taken place here, and while the larva was laying up for the purpose the leaf grew sufficiently to allow it later to mine normally parallel to the long axis till again arrested in the bulb and forced once more to zigzag.

Frequently in old leaves the mines may be found to terminate abruptly, or several inches may be missing; examination of the plant will reveal the continuation of the mine, or the missing portion, on some other leaf, and further examination will show that both leaves, at the time of the change, had been in close apposition to one another in the bulb, the larva having mined from one into the other, and perhaps later back again. One may find not a mine, but only a very faint and slight impression of one, on the surface of an otherwise sound leaf; this is due to the pressure caused by the larva mining in the leaf next against it while in the bulb. Never more than one larva will be found to be mining in one half of a leaf, but both halves of the same leaf may be mined by separate larvae. In such cases there is, as one would expect, a direct parallelism in the course of the mines. Occasionally very short blind branches or ends may be found at the angles of the mine, the midrib or outer edge of the leaf, however, preventing farther progress in that direction.

The mine is usually on the under-side of the leaf, and is there very conspicuous; when appearing on the upper surface it is, as a rule, not so marked. The colour varies, with age, from green to dark brown. Frass is almost negligible; it is deposited in a fluid or semifluid state at intervals in small amounts, and tends to stain the leaf-substance brownish.

In the next to last larval stadium the larva, practically mature, ceases mining (the gallery is now some 3–4 mm. wide), and, leaving the gallery, forces its way, no longer downwards, but straight up for about 1½–2 in., till just below where the two contiguous leaves begin to separate; here, lying with the head uppermost and parallel to the axis of the leaf, it rests awhile; its body becomes much distended with clear fluid, and within it can be seen the next stadium larva about two-thirds the length of the old distended skin. When ready it bites a hole in the side of the old skin and emerges from it, the cast skin being flattened against the surface of the leaf, to which it may adhere for many months. The larva is now in its final stadium, the whole of which is occupied in the preparation of the cocoon, and lasts eight to fourteen days. Total length of the mine, possibly 3–4 ft.

The Cocoon. (Plate 26, fig. 2.)

This is constructed in rather a peculiar way. The larva, having moulted as above between two applied leaves, makes a transverse cut of about 3-4 mm. in the outer (under) cuticle of the inner leaf, and, working upwards, insinuates itself under the cuticle: then, turning, it repeats the performance downwards, forming a shallow somewhat elliptical-shaped cavity between the cuticle and remainder of the leaf. The transverse cut extending across its middle is now repaired with silk on the inside, and in the completed cocoon is difficult to find. The thin outer cuticle receives a liberal strengthening of silk on the inside, but the remainder of the cocoon-cavity receives little or none. As the leaf grows in length it carries the cocoon up with it, and in a few months it is some little distance above the ground, and so offers no difficulty to the emerging imago. The exposed cocoon is by no means conspicuous; externally, it is usually covered by the larval skin cast prior to the last stadium. It is shallow, elliptical, its ends somewhat pointed and depressed into the leaf; its long axis is parallel to that of the leaf; average size about 15 mm. by 3 mm. Owing to pressure by the larva while the leaves are still closely applied to one another, the leaf on the outside of the cocoon receives a hollow depression. The pupal stage lasts six to seven months, from February till mid-August.

The Pupa. (Plate 31, figs. 1–3.)

The pupa lies in the cocoon in an upright position, its ventral surface innermost. Colour at first pale creamy white, becoming later light brown, darker on dorsum, to black with pale markings on wings prior to emergence. It is somewhat compressed dorso-ventrally, the ventral surface being more or less keeled or prominent along the mid-line, so that a transverse section about the fourth abdominal segment would be broadly triangular in shape. The shape of the pupa is frequently influenced and even slightly deformed by external pressure caused while the cocoon is still in the bulb.

Male. The head as seen in profile from before or behind is square-shaped, due to the lateral prominence of the basis of the antennae; viewed from the side it is bluntly rounded. Ventral view: Front broad, roughened; fronto-clypeal suture represented by a shallow transverse depression; labrum small, on either side of it a small rounded area possibly representing the mandible; eyes relatively large, soon become dark brown to black, the eye-cap, that portion of the antenna covering the hinder part of the eye, rather prominent and roughened with small transverse rugae; labial palpi ill-developed, short, constricted at $\frac{1}{4}$, slightly bulbous caudad, only about two-thirds the length of maxillae; maxillae short and broad, do not quite reach antennae laterad, they meet in the mid-line below labial palpi; coxae have a narrow origin above between maxilla and antenna and first leg, otherwise about one-fourth as broad as long; the first legs meet in mid-line for their lower third; the second legs together with antennae extend to about mid-point of pupa; appearing from beneath the former are the third legs, more or less covered laterad, especially above, by a portion of hindwings, which here appear from beneath anterior margins of forewings; all three structures terminate about the level of junction of segments 4 and 5. Dorsal view: The vertex is narrow in its mid-third, being somewhat expanded laterad against antennae; the front is broad and head devoid of cutting-plate or other specialized structure of like nature; the prothorax is much expanded against antennae, but in its mid-third is very

narrow; mesothorax is prominent and large; metathorax about half as long as mesothorax, all three thoracic segments and vertex possess a median longitudiual sutural line; the hindwings pass beneath forewings to about level of spiracle on third abdominal segment. Abdominal segments of about equal length from 1 to 7 inclusive, 4 and 5 being if anything slightly larger, in width they become successively smaller from 5 to 10, this latter being small and bluntly rounded; on dorsum of each segment 2–8 inclusive are two pairs of shallow depressions; there are no tubercles or setae, no tubercular scars, spines, or cremaster; there is apparently no movement. The spiracles on segments 2–8 inclusive are small, circular, dark brown, and are conspicuously situated on large flattened slightly-raised eminences. The genital aperture is prominent ventrad between 9 and 10. The entire body is slightly roughened with fine transverse rugae, these being somewhat coarser on the thoracic segments and appendages.

AVERAGE MEASUREMENTS OF PUPA.

Measurement at	Length from Extreme Front.	Transverse Diameter.	Ventro-dorsal Diameter.
	Mm.	Mm.	Mm.
Bottom of labrum	0·59	1·52	1·13
Bottom of labial palpi	0·93	1·70	1·20
Bottom of maxillae	1·17	2·00	1·24
Bottom of first legs	3·49	2·55	1·39
Bottom of second legs	4·49	2·50	1·39
Bottom of antennae	4·55	2·45	1·35
Bottom of wings	5·38	2·15	1·28
Bottom of third legs	5·51	2·35	1·24
Extreme length	9·31	..	..

Dehiscence.

This takes place within the cocoon, the pupa not being extruded. The moth forces its way through the upper end, the outer covering of the cocoon here being only lightly bound around its edge. In the pupa splitting takes place transversely along the epicranial suture, and vertically downwards on either side behind antennae from epicranial suture above for a short distance between antenna ventrad, and vertex, prothorax, and a small portion of forewing dorsad. There appears to be no further splitting, and there is no detachment of any of appendages.

(25.) **Apatetris melanombra** Meyr. (The Akeake-moth). (Plate 27, figs. 2–4; Plate 29, figs. 1–8; Plate 30, figs. 1–4.)

Apatetris melanombra Meyr., *Trans. N.Z. Inst.*, vol. 54, p. 165, 1923. *Epiphthora melanombra* Meyr., *Trans. N.Z. Inst.*, vol. 47, p. 206, 1915; vol. 20, p. 77, 1888: Fereday, *Trans. N.Z. Inst.*, vol. 30, p. 363, 1898: Hutton, *Index Faunae Novae Zealandiae*, p. 118. *Gelechia sparsa* Philp., *Trans. N.Z. Inst.*, vol. 50, p. 128, 1918.

The Imago. (Plate 29, fig. 1.)

Meyrick's Original Description.—See *Trans. N.Z. Inst.*, vol. 20, p. 77, 1888.

Type in Mr. Meyrick's collection.

A much paler form occurs in Dunedin; it was described by Mr. Philpott as *Gelechia sparsa*, poor specimens accounting for the mistake in the genus. I have been able to observe and rear a long series of both forms; the pale variety does not appear to occur in the North Island, whereas in Dunedin both forms have been reared from the same food-plants, the lighter variety being by far the commoner. Mr. Philpott's description appears in *Trans. N.Z. Inst.*, vol. 50, p. 128, 1918.

To his description may be added that the costal half of the forewing is far more densely irrorated with brown than the dorsal half. The size of the moth varies considerably according to the amount of food available. Examining all the stages and characteristics in the life-history of these two forms, I could find no points of difference whatever, and conclude that the pale form is only a southern variation of the dark species. I understand Mr. Meyrick has come to the same conclusion without any reference to the early stages.

Distribution.

The first specimens discovered were reared at Christchurch in November (1886?), by Mr. R. W. Fereday, from mines in *Olearia avicenniaefolia*, and were reported common. The moth appears to be well distributed through New Zealand, having been found on Mount Egmont at 3,500 ft. (North House), common, 20th December, 1917; Wanganui, common, larvae and pupae in September; Wellington, common, larvae in June and October, many pupae in December, the imagos emerging early in January; Governor's Bay, exceedingly common; Dunedin, so common as to have become almost a pest in some localities. There are probably two, if not three, generations; larvae, pupae, and imagines may be found throughout the summer months, though the best time to collect mines for rearing purposes is towards the end of November.

Food-plants.

Olearia furfuracea, *O. Traversii* (akeake), *O. arborescens*, *O. divaricata*, *O. macrodonta*, *O. Colensoi* (tupare), *O. avicenniaefolia*, *O. lacunosa*, *O. Cunninghamii* (akeake, heketara), *Celmisia verbascifolia* (mountain-daisy), *Celmisia Dallii*.

The Ovum.

Class, flat. Colour pale yellow, empty shells grey. Shape, as seen from above, slightly elongated oval, sides slightly flattened, micropylar end slightly flattened and wider than its nadir, which is bluntly rounded. Sculpture, none. Shell roughened, shiny, very strong. After the larva is hatched the empty shell becomes filled with frass-granules, and may remain attached to the leaf for many weeks.

Average dimensions: Length, 0·40 mm.; greatest width, 0·24 mm.; greatest height, 0·22 mm.

Egg-laying.

Eggs laid singly and firmly attached to upper surface of leaf, generally in close proximity to midrib or one of the coarser veins. Ova relatively large and easily found by the naked eye. Numbers of ova may be found on some leaves, but are presumably not all deposited by the one parent;

later this will result in serious overcrowding and the last larvae to hatch will not reach maturity. On hatching, the larva burrows directly through the shell into the leaf-substance, the empty shell becoming filled with frass and firmly retaining its position.

The Mine. (Plate 27, fig. 2; Plate 29, fig. 2.)

The chief characteristics of the mine are: Firstly, the preliminary 6 or 7 millimetres of the gallery are closely convoluted, vermiform, or spirally wound round the point of entrance; secondly, a narrow gallery of 2 in. to 3 in. length; thirdly, an irregular expanded blotch of varying size, usually about ½ square inch in area. Hatching is revealed by the dark discoloration of the leaf-substance under the ovum. The mine throughout its length is close beneath the upper cuticle of the leaf, and is very conspicuous; there is very little sign of it on the under-surface. In the second part of the mine the gallery increases evenly in width; its borders are more or less even, depending chiefly, however, on the nature of the leaf, as also does the general course of the mine. In the North Island akeake (*O. Cunninghamii*) the coarse network of veins causes the direction of the gallery to become tortuous, and the margins very irregular, whereas in *Celmisia verbascifolia*, with its almost parallel veins, the gallery is in almost all cases comparatively straight, occasionally looped back upon itself either on the same or the other side of the rib that it is following; here, too, the margins of the gallery are uniform and even. There is rarely any tendency to the formation of blind branches. The midrib, except in its terminal part, forms an effectual barrier to the young larva. In its terminal part the mine expands into an irregularly shaped blotch. Where several larvae are mining in the same leaf their mines do not tend to cross one another or coalesce unless or until the available leaf-substances become scarce; in such cases one may find several larvae working in a common blotch produced by the coalescence of the several galleries. The cuticle over the mine when fresh is sufficiently transparent for the grey frass to be seen within the mine, but it rapidly dies and dries, becoming dark brown and very conspicuous, the more so since the leaf-substance in close proximity to the gallery becomes at first paler in colour; later all the leaf-substance that has been cut off from its direct sap-supply by the mine dies and becomes almost indistinguishable from the mine itself, exaggerating the size of the mine. Mined leaves usually die and fall shortly after the emergence of the imagines. Frass is finely granular, and more or less fills the gallery.

Habits of the Larva.

The first moult takes place where the first part of the gallery joins the second—that is to say, after the first moult the larva mines in a more set direction. The duration of the first stadium is subject to much variation owing to climatic conditions, and may be any time from a fortnight or even less in summer to several months in winter. The second moult occurs about 25–30 mm. beyond the first; the increase in the width of the gallery becomes more marked from this point on. The position of the moult is generally disclosed by a short diverticulum on the lateral margin of the gallery, within which will be found the cast larval headpiece. It is the obstruction by the cast headpiece that causes the larva

to mine to one side of it. Duration of the second stadium, about three weeks. The positions of the moults can easily be found in old mines by removing the leaf-cuticle under a dissecting microscope and searching for the easily-found cast head-capsules. The larva ceases feeding for two or three days prior to each moult. The third and final moult takes place within the cocoon at the time of pupation. Duration of third stadium, about four weeks. The transition from gallery to blotch in the third stadium is quite gradual, not abrupt, the blotch being only the expanded terminal part of the gallery. This is best seen in mines in the leaves of the *Celmisia*, for in *Olearia* the coarse network of veins causes the blotch to be composed of incorporated portions of the earlier gallery.

Average length of larva at end of first stadium, 3 mm.; at end of second stadium, 5 mm.; when fully grown, 8 mm. The final act of the larva is to construct the cocoon within the blotch. Larvae appear to hibernate during their first instar, or else within the cocoon before pupating. Larvae are most plentiful in January, August, and November.

The Larva. (Plate 29, figs. 3–8.)

Full-grown, 8–12 mm. Cylindrical, slightly flattened dorso-ventrally, greatest transverse diameter at prothorax, abdominal segments gradually tapering caudad. Head retractile, very dark grey to black. Prothorax possesses a black dorsal shield only lightly chitinized along mid-line; it also possesses a pair of small black ventral plates. Abdominal segments full and rounded, last segment possessing four small black areas around venter. True legs and prolegs absent and replaced by fleshy protrusible swellings at dorso-lateral and ventro-lateral margins of all thoracic segments and abdominal segments 1 to 7 inclusive; on thoracic segments the ventral swellings possess each a small incomplete chitinous ring within which are situated three minute setae. Colour grey with darker mid-dorsal stripe; before pupating the larva becomes much lighter in colour; in all stages the ground-colour is darker on dorsal and ventral surfaces. Spiracles small, circular, inconspicuous. Skin covered with minute thickened chitinous plates, these are largest on dorsal and ventral surfaces, and are absent over apices of segmental protuberances; on dorsum of each segment the skin between these plates is more chitinized than elsewhere, apparently in minute ridges radiating out from the plates; this extra thickening occupies a definite saddle-shaped area on dorsum directly between protuberances, behind which there is a narrow extension downwards. Setae microscopic.

The head-capsule and its structure are shown in the figures; all are camera-lucida sketches.

The chaetotaxy is very difficult to determine, owing to the minuteness of the setae; in the figure these are greatly exaggerated. Alpha is placed below beta in prothorax, but in all other segments beta appears to have been pushed directly ventrad to alpha by the fleshy protrusion before mentioned; epsilon is above rho on the prothorax, mesothorax, and metathorax, below it but still above the spiracle in the abdominal segments, absent in 9; eta is closely associated with kappa on all segments excepting 9; nu is placed at a distance from pi in the thoracic segments pi is normal; tau is a minute seta in front of the leg-swelling on the thoracic segments and abdominals 1–7; sigma is normal; there are a number of minute subsidiary setae as shown in the figure, but the

importance of these cannot be estimated till other species of this and closely allied genera have been observed.

The Cocoon. (Plate 27, figs. 3, 4.)

An oval structure of white silk constructed within blotch-mine. It is attached to both roof and floor of mine, over which surfaces the silk is not so thickly deposited as elsewhere. Circumference is usually thickly covered with frass-granules. Average length, 7 mm.; width, 3 mm. The final act of the larva prior to pupating is to prepare a small circular trap-door for the time of emergence; this is generally in floor of cocoon, but may sometimes be in roof towards anterior end; occasionally there are two trap-doors, one at either end. The trap-door is kept shut by several strands of silk, its average diameter being 1·5 mm. Construction of the cocoon occupies three to four days.

The Pupa. (Plate 30, figs. 1–4.)

Cylindrical in shape, slightly flattened laterad, extremities bluntly rounded. Head possesses no specialized structures and is devoid of sculpture; labrum well up between eyes; mandibular areas small; maxillary palpi apparently absent; labial palpi either not shown or only a minute portion to be seen directly caudad to labrum in a slight V between maxillae; maxillae broad above, but much constricted in caudal half, extending as far as mid-point of pupa slightly beyond first legs; have a slight transverse wrinkling; antennae narrow, meet in mid-line at about their middle and extend to about lower level of seventh abdominal segment in female, and as long as forewings in male; show no distinct segmentation. First legs occupy all space between antenna and maxillae below eye and extend not quite so far caudad as maxillae, slight transverse wrinkling; second legs occupy short interval between antennae and first legs, they do not extend so far caudad as the latter; slight transverse wrinkling; forewings firmly soldered down to ventral wall and occupy about half ventral aspect of pupa, they meet in mid-line below antennae and extend as far as lower extremity of eighth segment in female and caudal extremity of pupa in male, are sculptured with rather coarse transverse rugae; third legs not seen; only a very short strip of hind-wings to be seen dorso-laterally as far as second segment. Prothorax somewhat expanded against antennae but practically lost in mid-third; it bears two pairs of short setae - one dorsal, one lateral. Mesothorax forms a prominent hump in dorsal profile, possesses a slight medio-dorsal ridge, and is sculptured with fine transverse rugae; possesses four minute setae on either side. Metathorax small, it also has four minute setae on either side of caudal extension of mesothorax. Pupal skin covered with minute thickenings of cuticle as in larva. Abdominal segments possess minute setae, segments 4–8 inclusive having one dorsal to spiracle on either side and two closely approximated and ventral close against dorsal wing-margin; segments 1, 2, and 3 all possess dorsal setae, but wing covers ventral pair except in 3 where one of the setae is free; 9 and 10 possess no setae. On dorsum of all abdominal segments excepting last two is slight transverse ridge caudad. Apparently no movement once pupal skin has hardened. Spiracles small, circular, dark brown, slightly elevated, those of segment 1 overlaid by the dorsal wing-margins. No cremaster. Colour of pupa golden brown. Average duration of pupal stage about thirty days.

AVERAGE MEASUREMENTS OF PUPA.

Measurement at	Length from Extreme Front.	Transverse Diameter.	Ventro-dorsal Diameter.
	Mm.	Mm.	Mm.
Bottom of eyes	0·53	1·00	1·00
Bottom of first legs	2·41	1·24	1·47
Bottom of second legs	2·12	1·24	1·47
Bottom of maxillae .	2·59	1·24	1·47
Bottom of antennae ..	4·17	0·53	0·55
Extreme length	4·53	..	..

Dehiscence.

Pupa not extruded from cocoon. Transverse splitting occurs along epicranial suture. Maxillae, eye-pieces, labrum, mandibles, clypeus, and front remain in one piece, are detached above but remain fixed to puparium caudad. Legs and antennae on either side become detached from wing-margins above. Medio-dorsal splitting through prothorax and mesothorax. Further transverse splitting occurs between prothorax and vertex, vertex thus becoming wholly detached; it, however, generally has one or two slips of integument holding it to puparium.

(26.) **Philocryptica polypodii** Watt (The Polypodium-moth). (Plate 27, fig. 1; Plate 28; Plate 30, figs. 5–8; Plate 31, figs. 4–11.)

Harmologa polypodii Watt, *N.Z. Jour. Sci. & Tech.*, vol. 4, p. 257, 1921. *Philocryptica polypodii* Meyr., *Trans. N.Z. Inst.*, vol. 54, p. 164, 1922.

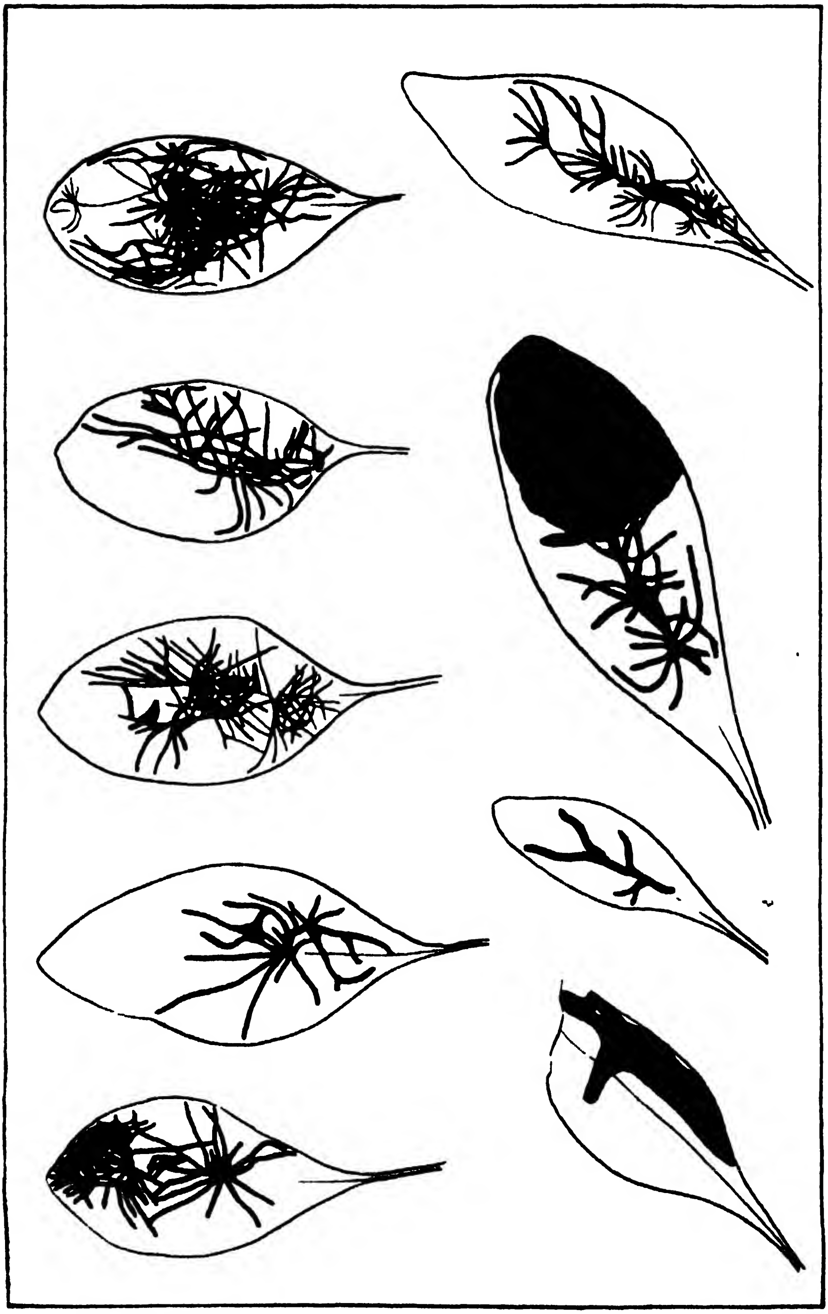
The Imago.

A pretty little moth having an average expanse of 14 mm. Forewings in female light brown in ground-colour, with a conspicuous dull reddish outwardly-oblique band near apex, and inner third of costa clothed with dark-bluish scales, the remainder of wing with small darker-brown markings principally along dorsum, with a diffuse area of dark-bluish, black, and brown scales at tornus; hindwings brown. Male differs in that forewings are almost entirely dull-bluish excepting for small apical area beyond oblique bar which is almost black; average expanse, 12 mm.

The original description appears in *N.Z. Jour. Sci. & Tech.* above quoted.

General Notes.

This moth was first discovered in 1919, when reared from mines obtained in the Botanical Gardens, Wellington. Its coloration and markings give it excellent protection when resting amongst the dead or dying leaves of its food-plant, and it is possibly due to its inconspicuousness that it has not been taken before, since its mines are common in a locality worked very thoroughly by expert entomologists. In the resting position the wings are folded tent-wise over the body and the apices have the appearance of being pinched together. When disturbed the moth runs about actively with frequent momentary pauses, and when on the wing flight is rapid and erratic. I have never seen the imago in the field, but Mr. Hudson tells me he has taken two this last season. No parasites have as yet been obtained.



Mines of *P. polypodii* in leaves of *Polypodium serpens*. (Exact tracings, natural size.)

Face p. 336.]

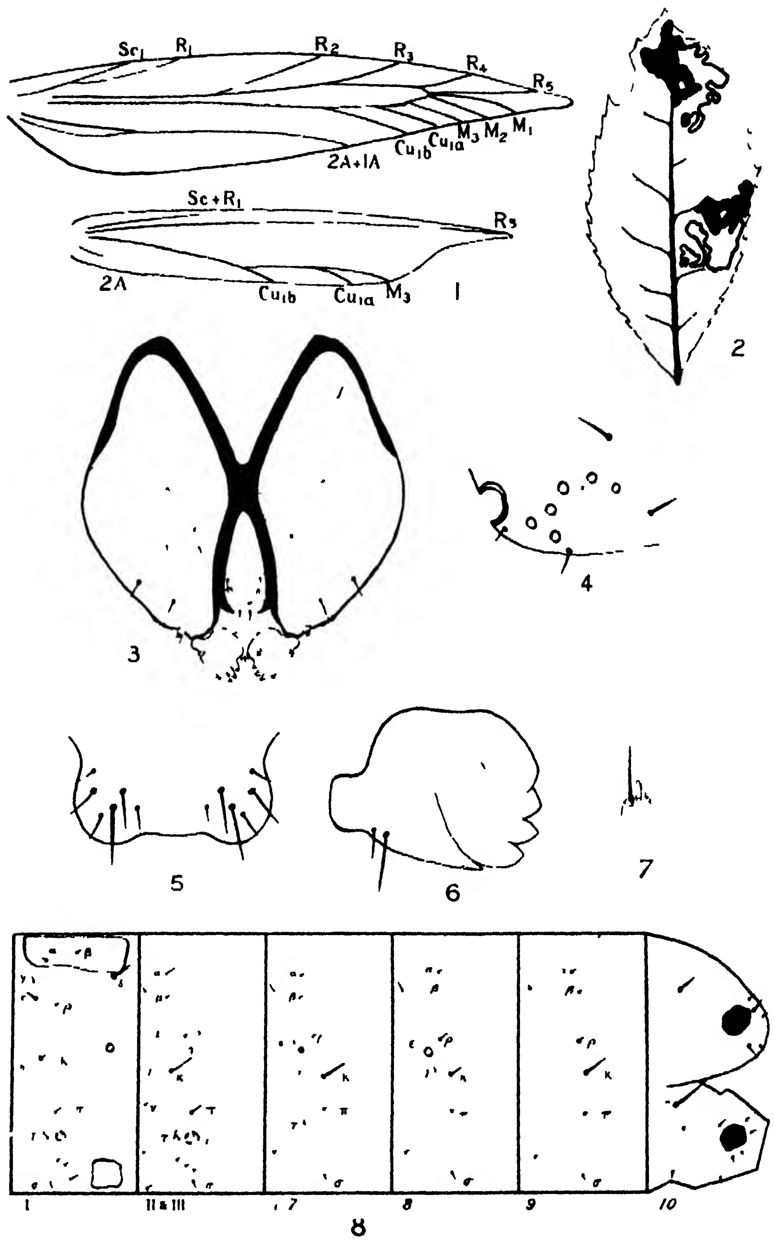


Fig. 1. Wing venation of *A. melanombra*.
Fig. 2. Mines of *A. melanombra* in leaf of *Olearia Cunninghamii*. (Reduced to about half.)
Fig. 3. Head capsule of adult larva of *A. melanombra*. (A camera lucida sketch from a cleared and mounted specimen. The labrum has been removed. The dotted lines indicate the structure of the ventral surface and its setae, and the internal skeleton.)
Figs. 4–7. *A. melanombra* larva: Arrangement of the eyes (4), labrum (5), mandible (6), and antenna (7).
Fig. 8. Setal map of adult larva of *A. melanombra*. (This also applies to the second instar.)

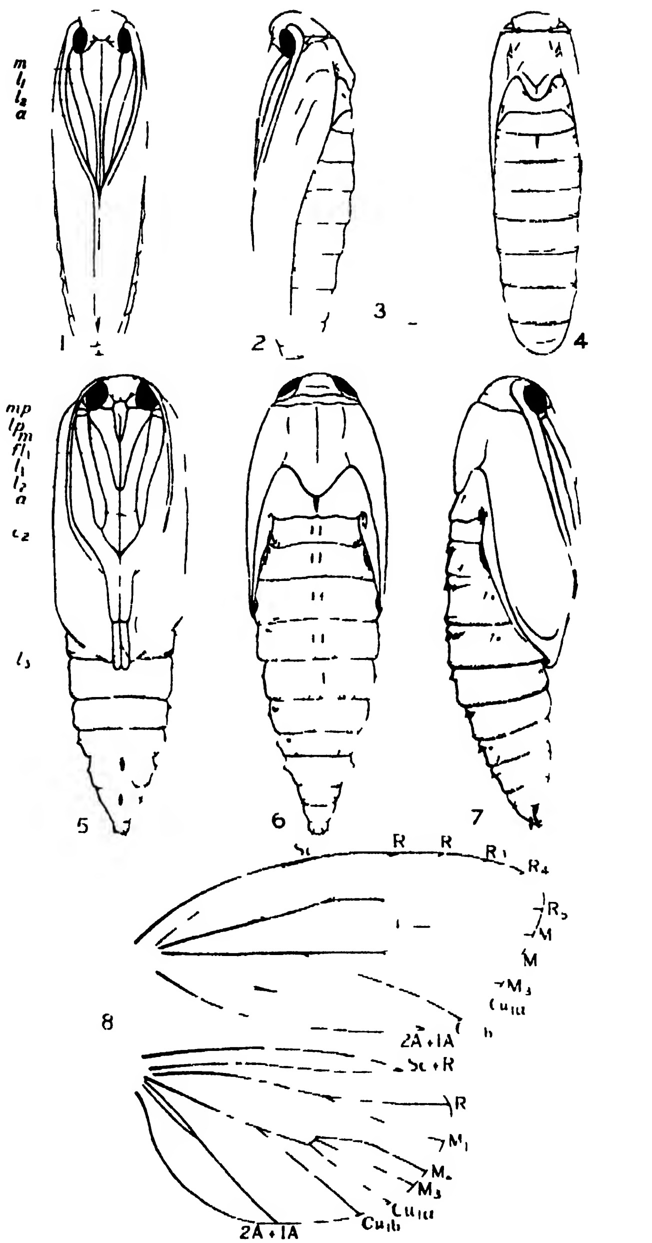


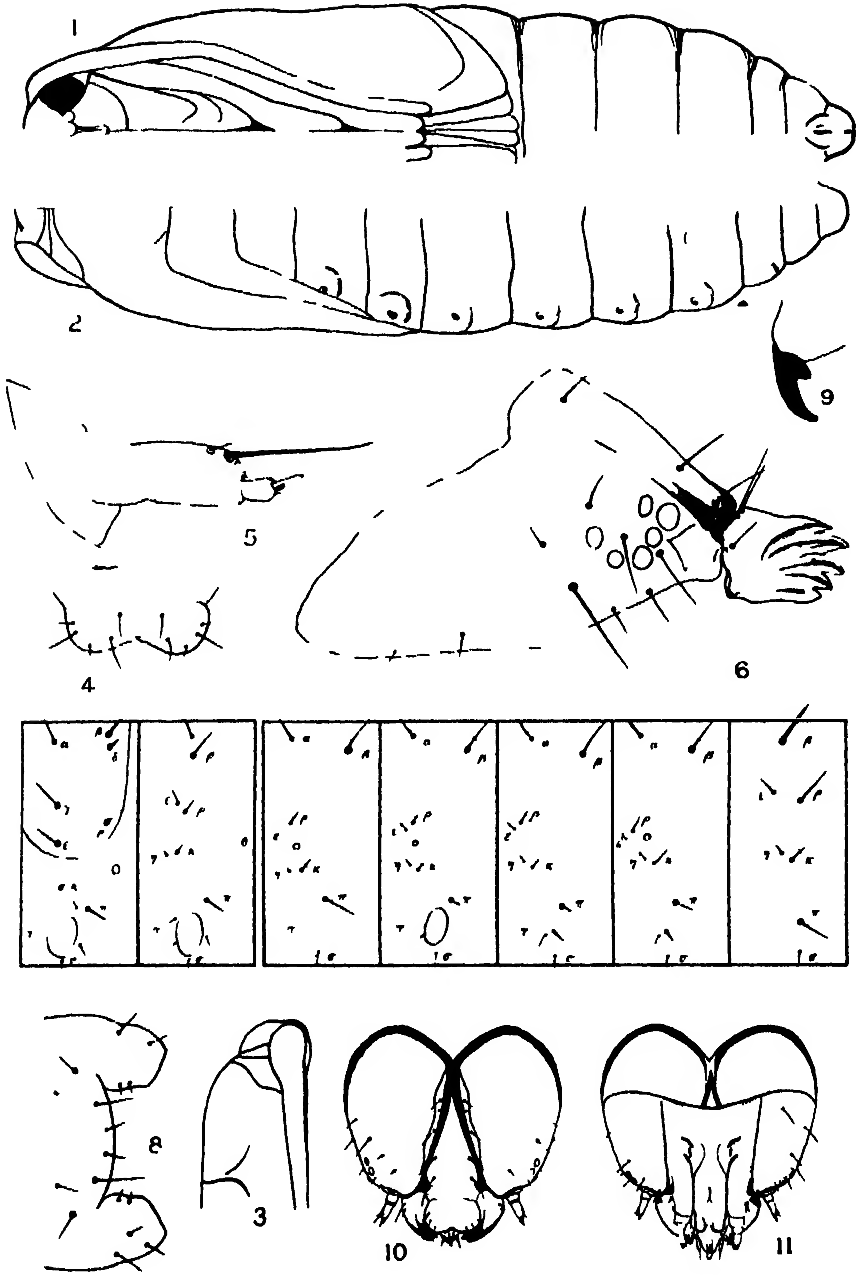
FIG 1 Pupa of I *melanombra* (female), ventral aspect *m*, maxilla *l_1*, first leg, *l_2*, second leg, *a*, antenna

FIGS 2–4 The same lateral aspect (2), lateral aspect of last abdominal segments of male pupa (3), dorsal aspect (4)

FIG 5 Pupa of *P polypodii*, ventral aspect *mp*, maxillary palp *lp*, labial palp, *m*, maxilla *fl_1*, femur, first leg, *l_1*, first leg *l_2*, second leg, *a*, antenna, *c_2*, coxa of second leg *l_3*, third leg

FIGS 6, 7 The same, dorsal and lateral aspects

FIG 8 Wing venation of *P polypodii*



Figs. 1-3.—*C. [illegible]* pupa. Ventral aspect (1), dorsal aspect (2), lateral aspect of head (3).

Figs. 4-11.—*P. polypoda*, adult larva. Labrum (4), antenna (5), mandible and eyes (6), setal map (7), tenth abdominal segment spread dorsally (8), terminal claw of thoracic leg (9), head-capsule dorsal aspect (10), head-capsule ventral aspect (11).

Distribution.

First found as noted in the Botanical Gardens, Wellington. The larvae were obtained on 8th August, 1919, and commenced pupating during the first week of October, the imagines emerging from 20th October till 1st December, 1919. A plentiful number of mines and full-grown larvae were found at Wanganui on 26th September, 1921, and again at Wellington during the same week. I have received one doubtful specimen of the mine from Mr Philpott at Nelson, 29th December, 1921.

Food-plant.

Polypodium serpens (*Cyclophorus serpens*), a small thick fleshy-leaved tree-climbing fern, common throughout New Zealand.

The Ovum and Egg-laying.

Nothing at present known.

The Mine. (Plate 28.)

The mine in its earlier stages is a narrow gallery, commencing as a rule near base of leaf and in general running along midrib. From this gallery a varying number of blind branch galleries of varying lengths are given off, frequently having a common origin and presenting a stellate appearance. These radiating galleries rarely give off secondary branches, and in earlier stages of larva seldom reach outer margin of leaf. The leaves being relatively small and the larva voracious, the mine with its branch galleries soon occupies major portion of leaf and causes it to wither, whereupon larva forsakes the old leaf and enters a fresh one, the mine still being a gallery with blind irregular branches. As larva grows the gallery increases in width up to about 1·5–2 mm. In many cases a larva may forsake a leaf after having mined but a very short distance, and in consequence a number of leaves may be attacked by a single larva. In later stages the width of gallery increases up to about 3 mm., and ends finally in an irregular blotch which may occupy entire leaf. The mine from beginning to end is close against upper cuticle of leaf, and there is little or no evidence of it to be found on under-surface. The galleries cross each other in all directions, and the cuticle covering them very soon becomes light brown in colour, that over the final blotch becoming dark brown to black; frequently the surrounding leaf-substance dies and blackens, and masks the actual size of the blotch. Margins of galleries are even and parallel. Central portion of leaf is always the most mined, and the midrib offers no barrier whatsoever. It is rare to find more than one larva in a leaf. Frass is coarsely granular, dark green or brown to black in colour according to age, and is irregularly distributed throughout mine.

The Larva. (Plate 31, figs. 4–11.)

Length when full-grown about 12–14 mm. Cylindrical; ground-colour bright green, head and prothoracic shield dark grey-brown; skin transparent, disclosing a bright-green alimentary canal and dorsal vessel. Tubercles small, green; setae light grey. Skin covered with minute pile except in vicinity of tubercles. Thoracic legs normally developed; prolegs on segments 3–6 inclusive and 10; ventral prolegs possess complete circles of 16–18 crochets each, the anal prolegs possess only a semicircle of 10–12 crochets each. Spiracles small, circular.

The head-capsule and its setae are shown in the figure; arrangement of eyes, antenna, labrum, and mandible are reproduced in Plate 31, figs. 4–6, and need no further comment.

Alpha is a small seta present on all segments except 9; beta is larger and placed caudad to and below alpha except on the prothorax where it is nearest the meson, and on the mesothorax and metathorax it is included in the same tubercular area as alpha but situated almost directly ventral to it; on segment 9 tubercular areas of beta are continuous across dorsum. In prothorax cephalic row on shield contains alpha, gamma, and epsilon, caudal row containing beta, delta just below it, and rho which is caudad to and between gamma and epsilon and above and cephalad to spiracle; on mesothorax and metathorax rho and epsilon occupy same tubercular area, the latter being a minute seta placed above and in front of rho, whereas in abdominal segments it is below rho, and both are above and somewhat in front of spiracle excepting in 8 where they are entirely in front; on 9 epsilon again rises above rho. The kappa group contains eta and kappa both in the common tubercular area situated below spiracle and well in front on prothorax where the minute seta eta is directly cephalad of kappa, on remaining thoracic segments it is somewhat below and on abdominal segments is slightly above kappa; the group on abdominal segments being immediately beneath spiracle. Theta appears in mesothorax and metathorax as a minute isolated seta between and caudad to kappa and rho groups. Mu is absent. Pi occurs on all segments, it is closely associated with the minute seta nu on prothorax, the two occupying a common tubercular area above and slightly behind base of leg; on mesothorax and metathorax nu is far cephalad, and is absent on abdominals. Tau contains two setae in front of base of leg on thoracic segments, two minute setae on segments 1, 2, 7, and 8, three on segments 3-6, and is absent on 9. Sigma is present on all segments. The chaetotaxy of segment 10 has not been attempted, but the map of the setae is given in Plate 31, fig. 7.

Habits of Larva.

The nomadic existence of the larva has already been noted. The exit from mine may be either through upper or lower cuticle—there would appear to be no special choice; but the entrance into a fresh leaf is always through lower cuticle. In any exceptions to the above it will be found that the upper surface has been closely covered by another leaf. As a preliminary to commencing a fresh mine in a new leaf the larva will spin a slight canopy of silk under which it may gain a certain amount of protection and support. Twelve hours will see the larva totally within the leaf, and in order to get under cover as soon as possible it can contract into a remarkably short length—from 1 cm. to 4 mm. Moulting takes place within the mine; the number of moults and duration of stadia are not known. When disturbed the larva exudes a black fluid from the mouth, and if shaken from a leaf while outside the mine will utilize a fine silken thread by means of which it may find its way back.

The Cocoon. (Plate 27, fig. 1.)

This is a cylindrical structure of thin white silk constructed within the final blotch-mine. Usually in central portion of mine, and from its anterior end to outer margin of leaf there extends a slightly-curved silken

tunnel. At margin of leaf a narrow slit is prepared by larva prior to pupating. This slit is 2–3 mm. long and is usually slightly on under-surface of leaf. Tunnel is about 1 cm. in length and 3–4 mm. in diameter; the slit at its termination is not protected by silk but remains naturally closed. Frequently the leaves containing the cocoons wither and fall to the ground. The cocoon proper is about 1 cm. in length and externally is closely invested with frass-granules; a slight curtain of silk separates anterior end from tunnel. In dead leaves containing cocoons, these and their tunnels can readily be detected from the exterior on both aspects of the leaf since the surrounding cuticle becomes shrunken and so leaves them in relief.

The Pupa. (Plate 30, figs. 5 7.)

Pupa small but stoutly built, bluntly rounded cephalad, abdominal segments becoming attenuated caudad and terminating in a bluntly-pointed cremaster. Lateral wing-margins relatively straight and parallel, ventral profile of thoracic appendages well rounded, most prominent at level of second abdominal segment.

Head -front situated more dorsad than ventrad, possessing a pair of short dorsal setae; vertex not very distinctly defined; clypeus possessing three pairs of minute setae as shown in Plate 30, fig. 5; labrum with a slight tendency to be bilobular; eye but little covered by antenna; mandibular area relatively large and clearly defined; maxillary palpi short, situated caudad to eye and occupying short interspace above first leg between antenna and maxilla; labial palpi short and narrow; maxillae broad above but constricted caudad, about twice as long as labial palpi; antennae of about equal width throughout, not markedly segmented, do not extend beyond second legs in either sex, and are slightly longer in male than in female; first legs short and stout and about half length of second, their caudal extremities separated by second coxae; between maxillae and first legs, but not extending beyond the latter, lie the femora of first legs; second legs have a narrow strip above, are widest in mid-third, and, meeting in mid-line, lie closely adjacent in their caudal third, terminating about central point of pupa; forewings extend as far caudad as fifth abdominal segment, below second legs they are separated in mid-line by a small strip of hindwings, appearing from beneath which are the caudal extremities of third legs, which extend just slightly beyond forewings; a narrow slip of hindwing appears caudad to forewings. Prothorax narrow, restricted in mid-dorsal region, and somewhat expanded laterad; mesothorax with distinct mid-dorsal suture which extends also into metathorax. Beyond a slight microscopical roughness or pitting there is no sculpturing. Spiracles small, circular, and slightly elevated, those of first abdominal segment covered by hindwings. Abdominal segments 2–8 inclusive possess two transverse rows of dorsal spines, anterior row being slightly waved and possessing a single line of small stout spines, posterior row straighter, extends slightly farther laterad than anterior, and its spines are more minute and more numerous; in second segment anterior row is very poorly developed, whereas posterior row is most poorly developed in segment 8; dorsal row is present on segment 9 in male only and is poorly developed. Cremaster flattened dorso-ventrally and bluntly rounded at apex, bears a small series of 6–8 slender hooklets, mostly situated ventrad. Genital aperture apparently situated on segment 8 in female and on segment 9 in male, well developed; anal aperture well marked on segment 10.

Head-setae have already been mentioned, abdominal segments possess minute setae on same plan as larva; alpha and beta are both present on the mesothorax and metathorax, beta being closer to the dorso-meson; in the abdominal segments alpha is nearest dorso-meson, is the only seta on segment 1; segment 2 bears alpha and beta only; rho appears in front of and dorsal to the spiracle in 3; kappa, eta, and mu appear in 4, and in segments 5–9 inclusive setae are the same as in larva; 10 has no setae; proleg-scars are absent. Limited movement can take place between segments 2–3, 6–7; free movement between 3–4, 4–5, 5–6. Colour at first green, the abdominal segments becoming brown and later dark grey, darker on the dorsum; dorsum of thoracic segments dark grey to black, wings black mottled with brown, eyes black, appendages mottled golden brown and black.

Pupa to be found during October and early November. Length of pupal existence under favourable conditions about four weeks.

AVERAGE MEASUREMENTS OF PUPA.

Measurement at	Length from Extreme Front.	Transverse Diameter.	Ventro-dorsal Diameter.
	Mm.	Mm.	Mm.
Labrum	0·45	1·20	1·00
Bottom of labial palpi . ..	1·00	1·73	1·52
Bottom of maxillae . ..	1·73	1·86	1·73
Bottom of first legs . ..	2·24	1·86	1·86
Bottom of second legs . ..	3·45	1·73	1·73
Bottom of third legs . ..	4·00	1·40	1·40
Extreme length	6·00	..	..

Dehiscence.

The pupa forces its way along tunnel and is extruded from exit at margin of leaf as far as caudal extremities of forewings. Splitting occurs mid-dorsally through the whole length of mesothorax, prothorax, and dorsal head-piece. Transversely along epicranial suture, extending along entire hinder margins of antennae. Transverse splitting also occurs laterally between prothorax and mesothorax, and prothorax and dorsal head-piece, but these do not become wholly detached. The front, antennae, eye-pieces, and other head-structures all remain in one piece, but may become wholly detached from rest of puparium. Leg appendages on either side together with lower portions of eye-pieces are separated by mid-vertical splitting, and, becoming free from antennae laterad, form two plates entirely free below and only precariously attached above. Third legs remain attached to wing-cases and are not included in above.

Illustrated Life-histories of New Zealand Insects: No. 2.

By G. V. HUDSON, F.E.S., F.N.Z.Inst.

[*Read before the Wellington Philosophical Society, 30th September, 1921; received by Editor, 13th October, 1921; issued separately 8th July, 1924.*]

Plate 32.

I DID not originally intend to include the Coleoptera within the scope of these notes, but, having had the good fortune to breed four species during the past season, I am tempted to publish the results, more especially as these beetles all belong to families of whose preparatory stages little is known. On this occasion I also include an account of the life-history and habits of a member of the order Hemiptera (suborder Homoptera).

Order COLEOPTERA.

Family TROGOSITIDAE.

Leperina sobrina. (Plate 32, fig. 8.)

Leperina sobrina White, *Manual N.Z. Coleoptera*, 1, 178.

This interesting beetle is fairly common in the neighbourhood of Wellington. Its larva is found in burrows in the solid timber of various trees, the specimen actually reared having been discovered in the stem of a dead nikau-palm (*Rhopalostylus sapida*). The length of the full-grown larva is about ⅝ in. It is very stout, with a horny blackish-brown head; a semicircular horny plate on the back of the second segment and two smaller plates on the dorsum of each of the third and fourth segments. The hind-body is very soft and fat, ochreous-grey; the terminal segment is black and very horny, armed above with two strong projecting processes. (See Plate 32, fig. 9.) The pupa state is spent in the burrow inhabited by the larva, and the perfect beetle remains hidden in this retreat for many days after its emergence whilst its integument gradually hardens and acquires its natural colours.

Family CUCUJIDAE.

Cryptamorpha brevicornis. (Plate 32, fig. 5.)

Cryptamorpha brevicornis White, *Manual N.Z. Coleoptera*, 1. 221.

This very active beetle is often abundant under the loose bark of felled hinau-trees (*Eleocarpus dentatus*), especially when saturated with moisture. The larva (Plate 32, fig. 6), which is even more active, is found in similar situations. Its length when full-grown is about ½ in. The antennae are about three times the length of the head, the body elongate narrow and much flattened, dull greenish-brown with a pair of pale spots on segments 5–11 inclusive and a darker dorsal streak throughout. The armature on the terminal segment consists of a long forked process, rising almost vertically from the dorsum, and when seen from above very much foreshortened. This larva is almost certainly carnivorous. The pupa (Plate 32, fig. 7) is secreted in a crevice on the inner side of the bark, its terminal segments remaining enclosed in the old larval skin. The beetles emerged in December.

Family TENEBRIONIDAE.

Paraphylax varius. (Plate 32, fig. 1.)

Paraphylax varius Broun, *Manual N.Z. Coleoptera*, 1, 355.

This very remarkable beetle was discovered by Major Broun at Whangarei. It has occurred occasionally in the Wellington District, but is, generally speaking, a rare insect. The larva (Plate 32, fig. 2) inhabits the large shelf-like fungi (*Fomes*) which grow on the trunks of large forest-trees, apparently preferring those which have become detached and are in a partially decayed condition. Its length, when mature, is about ½ in. It is a cylindrical, bright ochreous-yellow grub, with a hard integument, furnished with six strong walking-legs and a shining reddish-yellow head; the second segment is rather large, covered with numerous short reddish bristles; the remaining segments are somewhat uniform in size with a dense row of reddish bristles around the middle of each; the posterior segment is furnished with a blackish horny ridge near its base, and two very large recurved hook-like processes at its extremity. This larva drills tunnels through the very hard inner substance of the fungus on which it feeds. About a dozen specimens were found in September, almost full-grown, and the beetles emerged in February. In the natural state the beetle has been found from August until April. Single specimens have usually been discovered adhering to the under surfaces of logs, but on one occasion I found over sixty specimens on a large detached fungus, from which evidently they had recently emerged.

Family MELANDRYIDAE.

Mecorchesia brevicornis. (Plate 32, fig. 3.)

Mecorchesia brevicornis Broun, *Bull. N.Z. Inst.*, 1, ii, 116.

This species is rather a rare beetle around Wellington. The larva (Plate 32, fig. 4), which was found under the bark of a recently felled rimu (*Dacrydium cupressinum*), is a rather elongate cylindrical grub, wholly ochreous, smooth, and shining; segments 5 to 9 inclusive are furnished with very prominent dorsal humps bearing on their summits numerous minute hooklets; the anal armature consists of two rather short, slightly recurved, horny processes. As only a single larva was found and reared, it is desirable that, when possible, the life-history be verified by the rearing of additional specimens.

This species was temporarily named *Hylobia nigricans* in 1890, but no description has been published under that name. Subsequently a description, which appears to refer to the same insect, was published by Major Broun, in 1914, under the name of *Mecorchesia brevicornis*, and I have adopted this name accordingly.

In connection with the special armatures present on the terminal segment in each of the beetle-larvae referred to above, it may be of interest to state that similar armatures are very frequently found on beetle-larvae which spend their lives in burrows in solid wood. The object of these remarkable structures is, I believe, to protect the larva from enemies approaching from behind. In many cases the burrow is so narrow that the larva cannot easily turn and bring its jaws into operation, and the need for some special means of defence from a rear attack is therefore obvious.

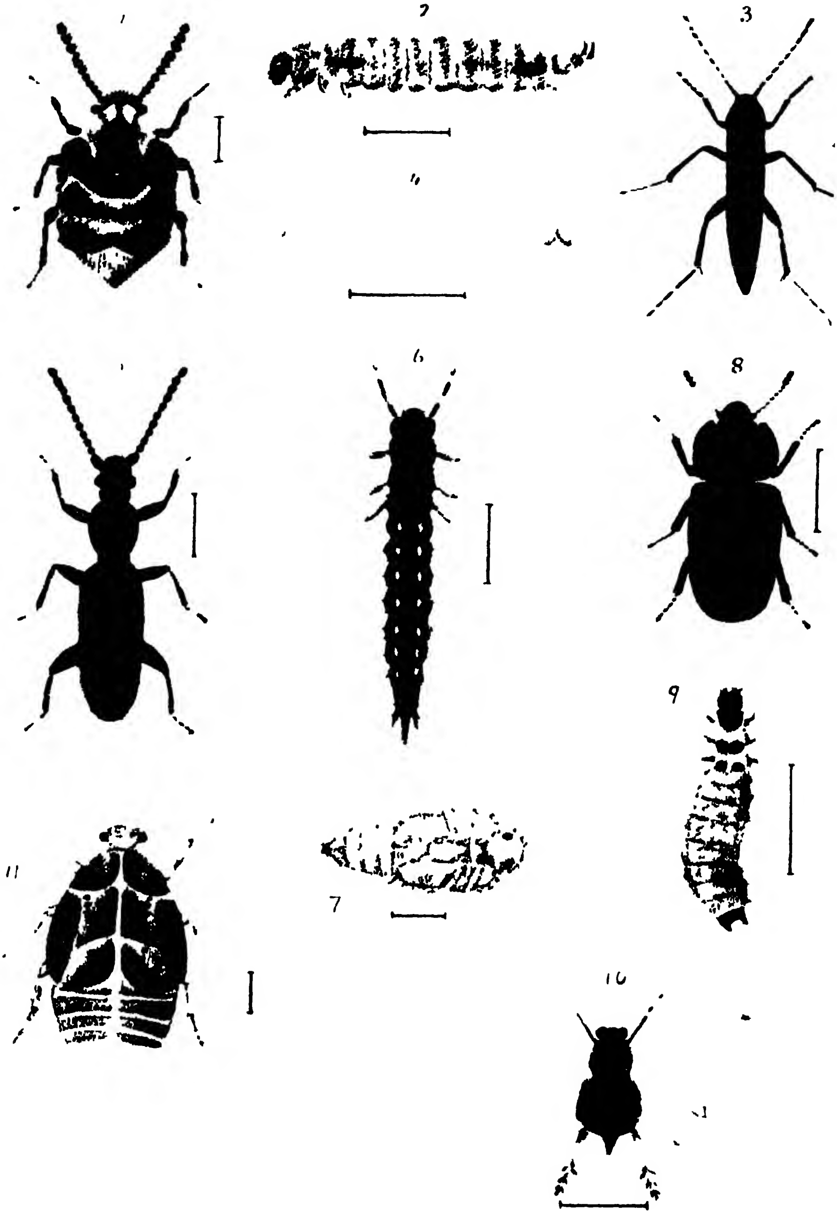


FIG. 1.—*Paraphylax varius* Broun.
FIG. 2. Larva of *P. varius*.
FIG. 3. *Mecorchesia brevicornis* Broun.
FIG. 4. Larva of *M. brevicornis*.
FIG. 5.—*Cryptamorpha brevicornis* White.
FIG. 6. Larva of *C. brevicornis*.
FIG. 7.—Pupa of *C. brevicornis*.
FIG. 8.—*Leperina sobrina* White.
FIG. 9.—Larva of *L. sobrina*.
FIG. 10.—*Oliarus oppositus* Walker.
FIG. 11.—Nymph of *O. oppositus*.

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Order HEMIPTERA.

Suborder HOMOPTERA.

Family CIXIIDAE.

Oliarus oppositus (Plate 32, fig. 10.)

Oliarus oppositus Walker = *O. marginalis* Walker: Hutton, *Trans. N.Z. Inst.*, 30, 186.

The nymph of this little frog-hopper may be found commonly, for most of the year, under logs and stones, and is of exceptional interest. (See Plate 32, fig. 11.) Its length when full-grown, excluding the woolly secretion attached to the three terminal segments of the body, is about ¼ in.; the rostrum, which reaches to the hind coxae, is thin but well developed; the antennae are inserted in concavities beneath the eyes, and apparently consist of two large and almost globular joints, a small cylindrical penultimate and a small setiform terminal joint. The nymph inhabits small cavities or tunnels under logs or stones which have been excavated by earthworms, ants, or other subterranean dwellers. The woolly substance attached to the posterior segments of the abdomen is extremely delicate and is very easily detached, so that loose fragments of it are sometimes found in the burrows frequented by the nymphs. These nymphs are often, though not by any means invariably, found closely associated with a large ant (*Ponera castanea* ? ?) On one occasion I observed an individual ant whose head had become involved in a mass of the fluffy secretion. The ant was making the most strenuous efforts to rid itself of the obstruction, using its forelegs with great vigour to that end. This incident suggested to me that the probable object of the fluffy secretion was to protect its owner from enemies. The nymph is fairly active, and the fluffy wool projects a considerable distance beyond the end of its body. Any predaceous insect or other enemy would thus be likely to seize hold of the fluff, and before it could get rid of this substance the nymph itself would have ample time to make its escape. The white colour of the fluff would also make it fairly conspicuous even in a very dim light, and would thus invite an enemy to seize hold of it. Nymphs when much handled soon lose the fluffy secretion, but I have found that it is completely renewed within the space of three days. Specimens are sometimes found having the "broad fluffy tail" considerably longer than it is shown in the figure. The perfect insect is found amongst grass and other vegetation throughout the summer.

Maori Plaited Basketry and Plaitwork: 2, Belts and Bands, Fire-fans and Fly-flaps, Sandals and Sails.

By Te Rangi Hiroa (P. H. Buck), D.S.O., M.D.

[*Read before the Auckland Institute, 14th December, 1922; received by Editor, 31st December, 1922; issued separately, 8th July, 1924.*]

Plates 33–40

INTRODUCTION.

Part 1 of this article (4) was confined to the technique of plaiting mats, baskets, and burden-carriers as it exists among the Whanganui tribes. In this second part use has also been made of any available information from other tribes.

1. BELTS AND BANDS.

Plaited bands are divided into two kinds—those used on the person, and those used in connection with the cooking of food. The bands used on the person as articles of dress or ornamentation are again divided into (*a*) fillets for the head, and (*b*) belts for the waist.

(*a*.) Fillets.

Narrow plaited bands of white wefts are used as ornamental fillets for the head. They are called *tipare* or *kopare*. Feathers used to decorate the hair are known as *pare*, as are also any bands or wreaths for the hair. The *tipare* forms a convenient support for the feather *pare*. Williams (1) also gives *kotaha* as "Part of a chief's head-dress, consisting of a fillet in which feathers are stuck." These fillets are usually plaited with four wefts, and when completed form a narrow band with serrated edges. The ends of the band are joined together to form a circlet which fits over the head above the brows. The technique is admirably shown in figs. 1–9, prepared by Mr. J. McDonald. Two sets of two wefts connected by a portion of undivided butt are interlaced to form a check as shown in fig. 1. In the figures the parts with parallel lines denote one surface of the weft, and the dotted part denotes the opposite surface. It will be seen that the edges are sharply defined by folding the underweft diagonally over the outer margin of the weft above it. In this bending or folding over, the other surface of the folding weft is exposed. If each stage is followed as described under the figures, the technique will be found to be quite simple.

This form of plaiting is very similar to a plait used in the making of European straw hats. Ratzel (2) figures a similar plait from Hawaii, and says it was probably introduced. The Maori say it is an old plait, and the Ngati-Porou Tribe of the East Coast call the plait itself *mekameka*. As Europeans in New Zealand were not in the habit of plaiting straw, it is difficult to see in what way they could have imparted such knowledge to the Maori. The Maori may have dissected an old straw hat and thus obtained the technique of the plait, but it seems to be definitely pre-European. (See Plate 33.)

Fillets of coloured flax-fibre woven after the manner of the *taniko*, or ornamented borders of cloaks, are very popular, but do not belong to this article.

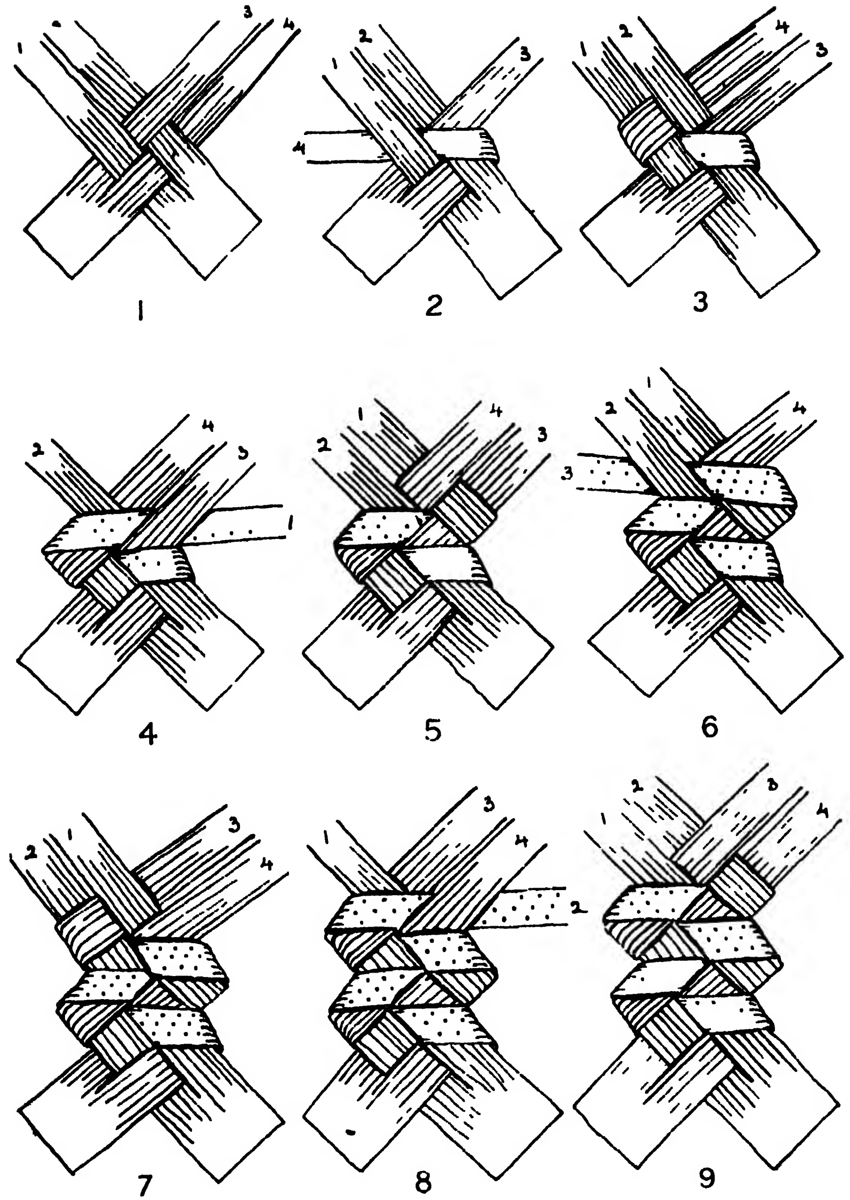


FIG. 1. Wefts in position: two dextral, two sinistral.
FIG. 2. Turn weft 4 to the left, and under weft 1.
FIG. 3.—Turn weft 4 diagonally to right, and under weft 2.
FIG. 4.—Turn weft 1 horizontally to right, and under weft 3.
FIG. 5.—Turn weft 1 diagonally to left, over weft 3 and under weft 4.
FIG. 6.—Turn weft 3 horizontally to left, and under weft 2.
FIG. 7.—Turn weft 3 diagonally to right, and under weft 1.
FIG. 8.—Turn weft 2 horizontally to right, and under weft 4.
FIG. 9.—Turn weft 2 diagonally to left, over weft 4 and under weft 3. This completes the cycle by bringing the numbered wefts back to the position they occupied in fig. 1. Carry on as from fig. 2, and continue until the required length is reached.

(*b*.) Belts.

Most of the Maori garments used as jupes or kilts had their own strings for tying round the waist. The waist-mat of the *piupiu* class, and the smaller aprons, or *maro*, were fastened on in this manner. Best (3) states that some of the *maro* were drawn between the legs and fastened behind to a belt. On ordinary occasions old woven cloaks were worn round the waist as a *rapaki*, or kilt, and such needed a supporting band or belt. A strip of flax, a cord, or a piece of rope was often all that was necessary.

The *kawe*, or burden-carrier, was often used by women as a belt. The usual way to carry a *kawe*, when not in immediate use, was to tie it round the waist. A single plaited band, of the same technique as one of the bands of the *kawe*, was also used as a belt. (See Plate 35, fig. 1.)

In addition to these, however, special belts were made. All belts come under the generic term *tatua*. The term *tu* was also applied to the belts used by warriors in battle. In old incantations referring to the preparations for combat the word *tu* is applied to the warrior's belt, and also to the special incantation recited when girding it on. Such a one is the following:—

Homai taku tu,
Homai taku maro,
Kia hurua,
Kia rawea,
Kia harapaki maua ko te riri,
Kia harapaki maua ko te nguha.
He maro riri te maro,
He maro nguha te maro,
He maro kai taua.

Give me my belt,
Give me my *maro*,
That they may be girded on,
That they may be fastened,
That I may be joined with Wrath,
That I may be united with Fury.
The *maro* is the *maro* of battle,
The *maro* is the *maro* of fierce anger,
It is the *maro* that destroys war-parties.

Men's Belts: *Tatua whara.*

These are plaited into a flat band, with white and dyed wefts of about ⅛ in. in width. They usually have coloured designs worked in them. On the east coast of the North Island they are also called *tatua pupara*, whilst on the west coast they are called *tatua kotara*.

The plaiting is commenced in the same manner as the beginning of the best floor-mats of the *porera* class (4). The white and black wefts are usually in sets of six or more, united by an undivided portion of the butt end of the leaf. The undivided portions help to lock the wefts when the plaiting is commenced. It is usual to have all the black wefts running the one way, and the white the other. The beginning-edge is carried on for a length of from 36 in. to 38 in. In Plate 34, fig. 1, it will be seen that all the sinistral wefts are black and the dextral white. The undivided butt ends show up well, with the black ends forming the upper layer, and the white the lower. In the belt figured the black ends are much longer than the white. The plaiting is carried on in the usual way with a twilled stroke. In the belt in Plate 34, fig. 2, there are, from the bottom or beginning, five horizontal rows of alternate white and black.

The first row is composed of white twilled twos, then follow black twilled threes, white twilled twos, black twilled fours, and again white twilled twos. In the row of black twilled threes, as the name implies, each black weft crosses over three whites, and in the twilled fours each crosses over four. Thus variety is added to the design by making the black bands wider than the white. These horizontal bands are termed *pae* by the Whanganui people. Further variety is now introduced by "changing the stroke" in each succeeding weft of the same colour. Thus in the succeeding set of black wefts each alternate black crosses one weft whilst the others cross two, and check and twill strokes are combined in the same row to change the pattern. The next set of white wefts continues the alternate twill and check, or two and one, and before the bounding even line of white twilled twos is reached the intervening spaces are filled up with black threes and ones. The result is a regular series of small white figures set in a black background, bounded above and below by white bands. This design is called *kowhiti* on the east coast of the North Island, and *mawhiti* in the west. Amongst the Ngati-Porou the term *kowhiti* is applied to the plait in which check and twill strokes alternate as it does in the *kowhiti* design above. The technique is carried on to form three double rows of the *kowhiti* motive, separated by black bands of twilled fours. As a convenient width has now been reached, the upper portion of the plaiting is finished off in horizontal bands of alternate black and white.

The side-edges are formed by turning the wefts back into the body of the plaiting without reversing the surface as in floor-mats. Thus it will be noticed that on the left of Plate 34, fig. 1, after the black sinistral wefts which go to the left have passed the left marginal dextral weft going to the right, the black sinistrals have no further white dextrals to interlace with. But from below up, as each black sinistral comes to the left side-edge of the plaiting, it is turned back at right angles into the body and functions as a dextral weft. Hence both sinistrals and dextrals to the left of the left marginal white weft are black, and the plaiting of the triangular portion bounded by the left border, the upper border, and the left marginal white weft is completely black. For the same reason the triangular portion to the right of the right marginal black weft is completely white. These triangles of one colour can occur only when all the wefts of one colour go in the same direction at the beginning-edge. The width of the completed plaiting is about 6 in., and the result is a strip of floor-matting 38 in. by 6 in.

On the upper border the wefts are left long without fixing or cutting. The upper and lower borders are folded back so as to conceal the ends of the wefts. It is usual to fold down the four corners a little more than the rest of the border. The band is now folded or doubled on itself, and the ends of the wefts kept tucked away out of sight between the two layers. This reduces the width of the belt to about 2½ in. The free edges are drawn together with a strand of prepared flax-fibre. In these days they are usually sewn together with needle and thread.

The cords for tying are generally attached by passing a length of prepared fibre of the requisite thickness through holes piercing both thicknesses of the band at either end. The fibre is drawn through to the middle of its length, the two halves brought together, divided into three equal portions, plaited into a cord with a three-ply plait, and finished off at the end with an overhand knot. In length the cords are 18 in. and upwards.

The belt is worn with the sewn edge uppermost. At times the edges are not sewn together, and the belt is then used as a pocket for containing various articles. Best quotes the tradition of Taukata having brought the *kao*, or cooked and dried *kumara*, to New Zealand in such a belt. The Aotea tradition states that Rongorongo, the wife of Turi, brought the seed of the *kumara* in her belt from Hawaiki. From this historical incident arises the saying applied to the *kumara* in the Taranaki district, *Te tatua o Rongorongo* (The belt of Rongorongo). The width of the belt may be more than 2½ in., some saying that it was made much wider so as to protect the abdomen from hostile thrusts on the battlefield. The uncut ends of the wefts tucked between the folds of the belt further thicken it and give additional protection.

Best (3) mentions that similar belts about 4 in. wide were used by women, and that in them the *whakakokikoki*, or zigzag design, was a favourite one. I have described the *kowhiti* design above in detail, as it also seems a favourite one in old belts. Various other designs were used. Other variations were secured by using alternate dextrals and sinistrals of one colour. The *pingao* (*Scirpus frondosus*) was used in coloured designs because of its yellow colour. Thus the colours used were, as in floor-mats and baskets, white, black, and yellow. In modern times European dyes are freely used.

Women's Belts: *Tu.*

These consist of several plaited strands, as against the single wide band in the men's belts. The available information was collected by Mr. Elsdon Best (3) from the Tuhoe Tribe. He was fortunately able to get samples made for the Dominion and Auckland Museums, and thus save this class of belt from being irretrievably lost. The strands are plaited after the manner of cords (*whiri*), and are quite distinct from the plaited bands of the *tatua whara* class, which is true plaiting, or *raranga*. The *tu* are worn by women only. Best distinguishes three varieties, from the material used—viz., *karetu* (*Hierochloe redolens*), *maurea* (*Carex lucida* and *C. comans*), and *muka* or prepared flax-fibre.

(1.) *Tu-karetu.*—These consists of a number of plaited strands (*kawekawe* or *kawai*), which have a *tau*, or plaited cord of dressed flax-fibre, attached to each end for tying round the waist. The strands are plaited with wefts of the leaves of the *karetu*, which are from 1½ ft. to 2 ft. in length. The midrib (*tuaka*) is removed from each leaf, as it becomes very brittle when dried, and thus breaks easily. The wefts are about ⅛ in. in width. The length of the many-stranded part of the belt varies. In those obtained by Mr. Best for the Auckland Museum they are 29¼ in., 34½ in., and 49½ in. respectively. The number of strands varies, being usually about ten. In the three belts mentiourd they are eleven, ten, and five.

The *karetu* wefts are plaited into a continuous braid, the length of which depends on the length of the belt and the number of strands required. Thus in the ten-stranded belt above the plaited *karetu* braid is 28 ft. 9 in. in length. The number of wefts is twelve, and they are usually plaited in the *rauru* pattern, the technique of which will be described when dealing with ropes and cords. It forms a neat flat braid about ¼ in. wide. Fresh wefts are added during the course of the plaiting. The requisite length having been attained, the cord is looped backwards and forwards so that when the ends of the loops are stretched apart the total length of the braid is divided up into a number of strands of the required length for the belt.

The *tau*, or flax-fibre cord, is attached in the following manner: The length of flax-fibre sufficient for plaiting the cord is doubled on itself. The loop or bight so formed is passed through one of the loops formed by the doubling-back of the *karetu* strands, and the two ends of the fibre passed through the bight, as in tying a single lark's-head knot. The bight is drawn tight round the loop of strands, and thus the flax-fibre is fixed, and one end of the belt sharply defined. The two ends of fibre are divided into three equal portions and plaited into a three-ply braid. It is usually about 2 ft. in length. As it thins out towards the end the three-ply braid may be changed into a two-ply twist and finished off with an overhand knot. The same process is repeated at the other end of the belt. When the belt has an uneven number of strands an end of the continuous *karetu* cord will be at each end of the belt. They are usually incorporated in one of the divisions of the *tau*, and plaited in with it for an inch or so to fix them. With an even number of strands both ends of the *karetu* braid will be at one extremity of the belt. They are then usually knotted together with a reef-knot. The *tau* are usually of black dyed fibre. Red-dyed fibre is sometimes used in addition to the black, in which case a length of one colour is looped round all the strands, whilst the other is looped round some of the

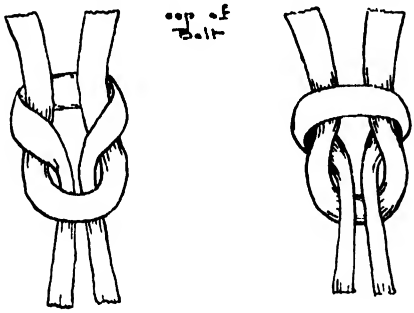


FIG. 10.- *Tu.* Fastening of *tau*.

strands, and usually crossed over the first loop. The plaiting of the *tau* is then of the *rauru* pattern. The black or red and-black tying-cords lend contrast to the yellowish *karetu* strands, improving the appearance of the belt. The *karetu* has a sweet-smelling odour, which recommended it to the women. (See Plate 35, fig. 2.)

(2.) ***Tu-maurea.***- This belt was sought after by women on account of the reddish-yellow colour of the *maurea* leaves when dry. It is made in exactly the same manner as the *tu-karetu*. The wefts are much narrower and more brittle. According to Best (3), they were strengthened by the addition of some flax-fibre. The *maurea* braid is about $\frac{1}{8}$ in. in width. The specimen in the Auckland Museum is 31 in. long with black flax-fibre cords of 20 in. each, and it has eleven strands.

(3.) ***Tu-muka.***—This is made altogether of *muku* (dressed flax-fibre). The one in the Auckland Museum has twelve strands, an equal number being red, black, and white. The strands are composed of round, thick cords about $\frac{1}{4}$ in. in diameter, and form a heavier, stronger, and better-looking belt than the previous two. The strands are prepared in a peculiar manner and, though not really coming under the heading of plaiting, Best's (3) description of the technique is included for the sake of completeness. The strands are composed of two cords, each of which has been prepared from

two threads twisted together by the *miro* process on the bare thigh. These two cords are then twisted together in a similar manner for a short section. "The operator then holds tightly the end of one of these cords and pushes the other back until, instead of enveloping the held cord in a long spiral, it appears to be *seized* round it at right angles." The same result would be achieved if one cord were stretched tight and the other twisted round and round it to make a close continuous whipping, but of course the Maori method is much quicker and simpler. The operation is carried on in sections. A section is twisted on the thigh (*miro*), and then pushed down (*koneke* or *pahuhu*); the next section is then twisted and pushed down, and so on until the required length is obtained. At the finish the pushed-down cord is knotted round the held cord. Each strand is prepared separately. The length of each strand is about 42 in. At either end of the seized strand there is a continuation of the two constituent cords. All those at one end are united by simply plaiting them on in a square plait to form the *tau*, or tying-cord. In the belt described the white cords are concealed under the red and black cords so that only the latter two colours show in the *tau*. Each *tau* is 26 in. long. As the *tau* thins out, the square plait is changed into a flat *rauru* plait, and the last 4 in. is finished off with a two-ply twist ending in an overhand knot. (See Plate 35, fig. 3.)

The many-stranded belt of the *tu* variety must be an old type, as it is found in Polynesia. The Niuean *kafa* is a belt composed of many strands of fine braid plaited from human hair. One in my possession contains sixty-nine strands, and is 35½ in. long. The hair-braid is continuous, and looped at either end of the belt to take the tying-cords. Percy Smith (5) mentions some as containing over a hundred strands. Similar belts are described from Tahiti.

COOKING-BANDS.

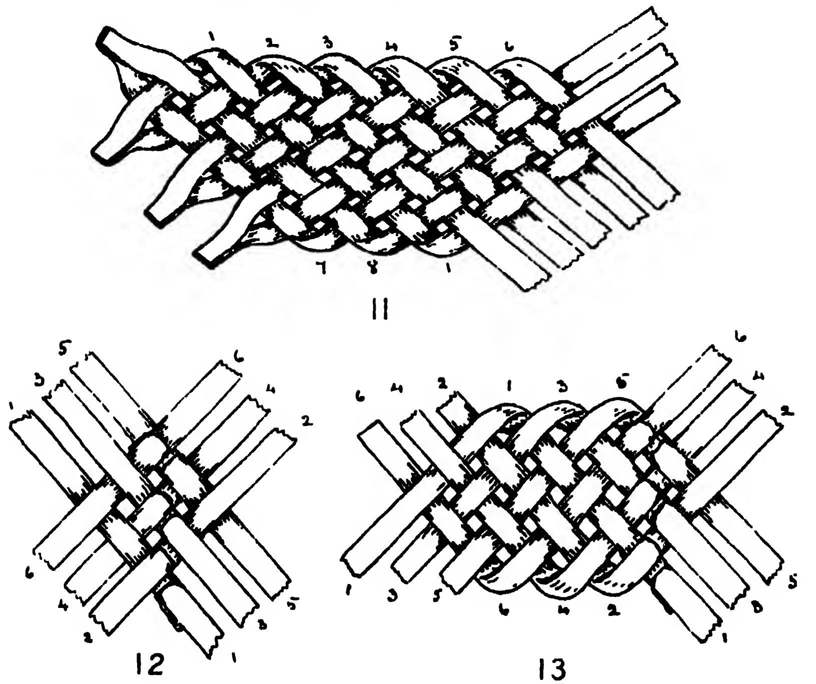
Bands used in connection with cooking are termed *paepae umu* (oven-bands) in regions on the west coast of the North Island. In other parts they are also termed *kopae*, *koropae*, *kopaepae*, *koropaepae*, *konae*, and *koronae*. They are used to place round the circumference of the *umu*, or *hangi* (earth-oven), to act as a raised rim, preventing the food heaped up on the heated stones from falling out. When the pieces of unburnt wood have been removed and the heated stones levelled, the *paepae* is placed in position, the food heaped in and covered with the *tapora* mats and a layer of earth to keep in the steam generated from the water that is sprinkled over the food. These bands may be divided into two kinds.

Paepae raranga: Plaited Band.

This a band 4 in. to 6 in. wide, made from green flax. The method is to take four full blades, remove the edges, bend the butts, and split down the blades to this bending, as in commencing the *kono*, or cooked-food basket. Each weft is thus a half-blade, and the wefts are in pairs connected by a portion of undivided butt. One pair of wefts is interlaced with a check stroke through the other three pairs, as shown in fig. 11. The upper left marginal weft, 1, is bent over at right angles to its course and interlaced through the others crossing it. The alternate wefts are separated into two layers to allow the crossing-weft 1 to pass between and continue the check pattern. The others, 2, 3, and 4, follow in order, the bending-over defining the upper border of the band. The lower border is commenced by the left lower marginal weft, 7, being bent upwards at right

angles and passing between the layers of alternate wefts. Weft 8 follows, and so the lower edge is defined. This process is continued, alternately working from the upper and lower borders, until the requisite length of 5 ft. or 6 ft. is reached. Fresh wefts are easily added by laying a fresh one over the shortening weft as it is bent back from the border and passed between the two layers separated for its reception, the butt end of the new weft being placed level with the border from which a shortening weft was bent back. The continuation of the plaiting locks the new weft in position. A simpler way is to push the butt end of the new weft back along the course of the shortening weft for the width of the band.

The ends of the wefts are cut short, and can be turned back and interlaced under crossing wefts to keep them in position. The two ends of the band are brought together and may be tied.



FIGS. 11-13.—Details of *paepae raranga* (plaited band).

The *paepae raranga* thus forms a continuous band which encircles the *umu*. It is set on edge, and is also called a *paepae whakatu* (upright oven-band). Being made of green flax, the wefts shrink and become loose after being used, at the most, twice, when they are cast aside and fresh ones made at no cost and little labour.

There is another variation of the plaited *paepae umu* made by the Ngati-Porou of the east coast. The full blades are bent at the butt as usual, but the two half-blades are opened out into a long single weft connected at the middle by the undivided butt portion. Six or more blades are used. Fig. 12 represents six blades laid down in the order of the numbers against them. They are crossed at their butt-junction in such a manner as to be alternately above and below—or, in other words, so as to continue a check plait. The plaiting is commenced with the six elements on

the left by defining the lower border of the band. Weft 2 is bent at right angles to its course by a half-turn backwards and passed under 4 and over 6. A half-turn forwards is just as good, but in the figure back-turns are shown. This weft must go under 4 and over 6 to continue the check plait. Weft 4 is now turned and passed under 6 (see fig. 13). The half-turns made define the lower border of the band. As there are no crossing-wefts for 6 to engage, some elements must be brought in from the upper set. The right one of the upper three, weft 5, commences the upper border just as the right one of the lower three commenced the lower border. Number 5 is given a half-turn forward and passed over 3 and under 1 as in fig. 13. Wefts 3 and 1 follow in a similar way, so that both borders and the width of the band are defined. The check plait is continued and the width of the band maintained as in the previous type described. Wefts reach the end in a point with an even number of wefts on either side: these are tied together to prevent the band becoming undone. The other half of the band is commenced by plaiting the six wefts on the right in a similar way. These wefts, it must be remembered, are the other halves of the flax-blades already used. Fig. 13 shows them in position, on the reader's right, ready for the start. Commencing at the lower border, it must be remembered that we are going in the opposite direction, and diagramatically the processes are reversed. Weft 1 takes a half-turn forward and passes in front of 3 and behind 5. Weft 3 follows suit and passes in front of 5. Weft 6 above takes a half-turn backward and passes behind 4 and in front of 2. This has to be done to keep up the same stroke. I have described it theoretically so as to follow the diagram and interest the reader with a plaiting problem. What really does happen on commencing the second side is that the plaiter simply turns the work over, when the wefts lie in the same direction as in the previous half of the work, and the work is done in exactly the same way. Thus, turn fig. 12 over mentally, maintaining the same upper and lower borders: the wefts to be plaited now lie to the left, and weft 1 will correspond to weft 2 in the previous half. It will take a half-turn backward and pass behind the first crossing-weft, which will be 3, and in front of the next, which will be 5. When the second half is completed the ends are tied together to correspond with the circumference of the earth-oven. Reference to fig. 12 will show that the plaiting was worked from right to left, whereas the other direction is that usually adopted. The woman I watched plaiting a *pae umu*, as it is usually termed in the east coast, plaited it in this way, and my notes and rough diagram naturally followed it.

This method aims at getting a longer weft and so avoid joining fresh wefts in, as in the usual west-coast method. The joining is done at the beginning, as it were. (See Plate 36, figs. 1, 2.)

A better class of band is plaited with narrower wefts which have been lightly scraped. The stroke used is often the *kowhiti*, where twilled twos and a check alternate. According to the plaiters, this thickens the band and assists it in standing on its edge. The twisted or braided band which follows was not used by the Ngati-Porou.

Paepae whiri: Twisted Band.

This variety is made from bundles of narrow wefts of flax, and plaited with a three-ply braid into a thick band of varying width. The wefts are of unprepared flax, and are narrower than the usual wefts for baskets.

Tipare (fillet for the head) worn by Rihipeti, the plaiting expert of Operiki, Wanganui River.

Face p. 352.]

Fig. 1.—*Tatua whara* (man's belt), opened out to show technique of edges, &c.
Fig. 2.—*Tatua whara*, folded and edges tucked in as when worn

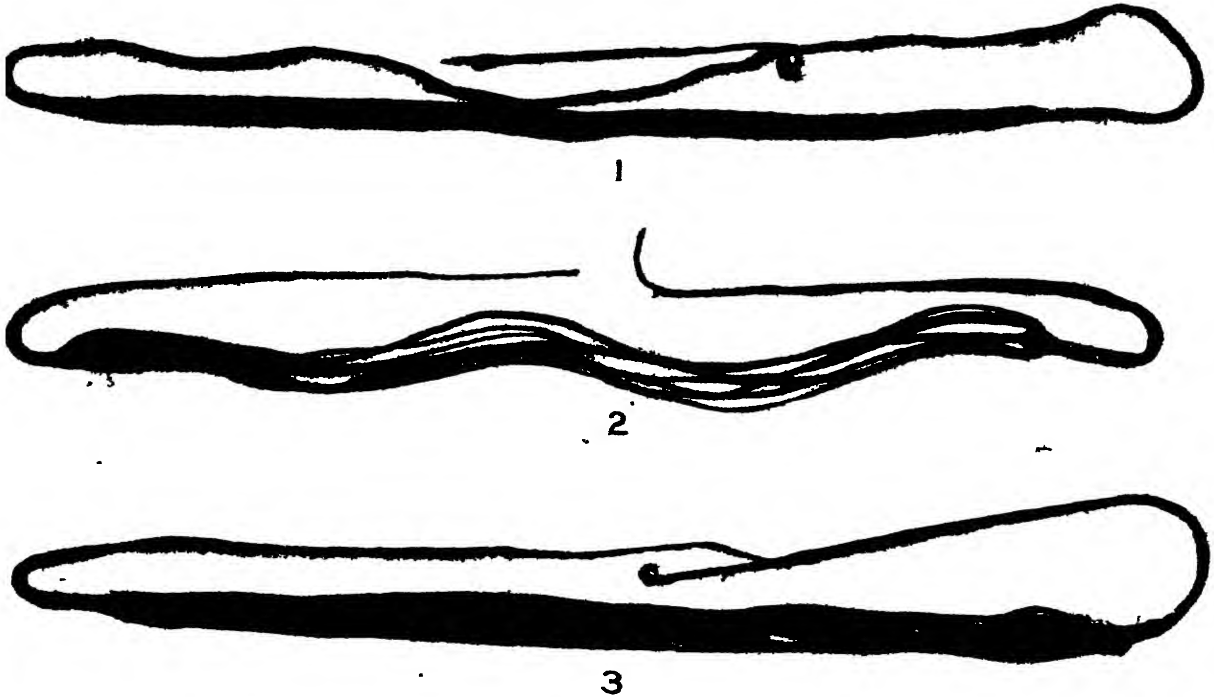


Fig. 1 Belt of single band of same technique as band of *taua*
Fig. 2 *Tu karetu* (woman's belt) made from leaves of the *karetu*
Fig. 3 *Tu muka* (woman's belt) made from scutched fibre of the *Phormium tenax*

2 3

Fig 1 *Paepae raranga* (oven band) The completed band
Fig 2 The band holding the food in position
Fig 3 –*Paepae whiri*, the twisted oven band

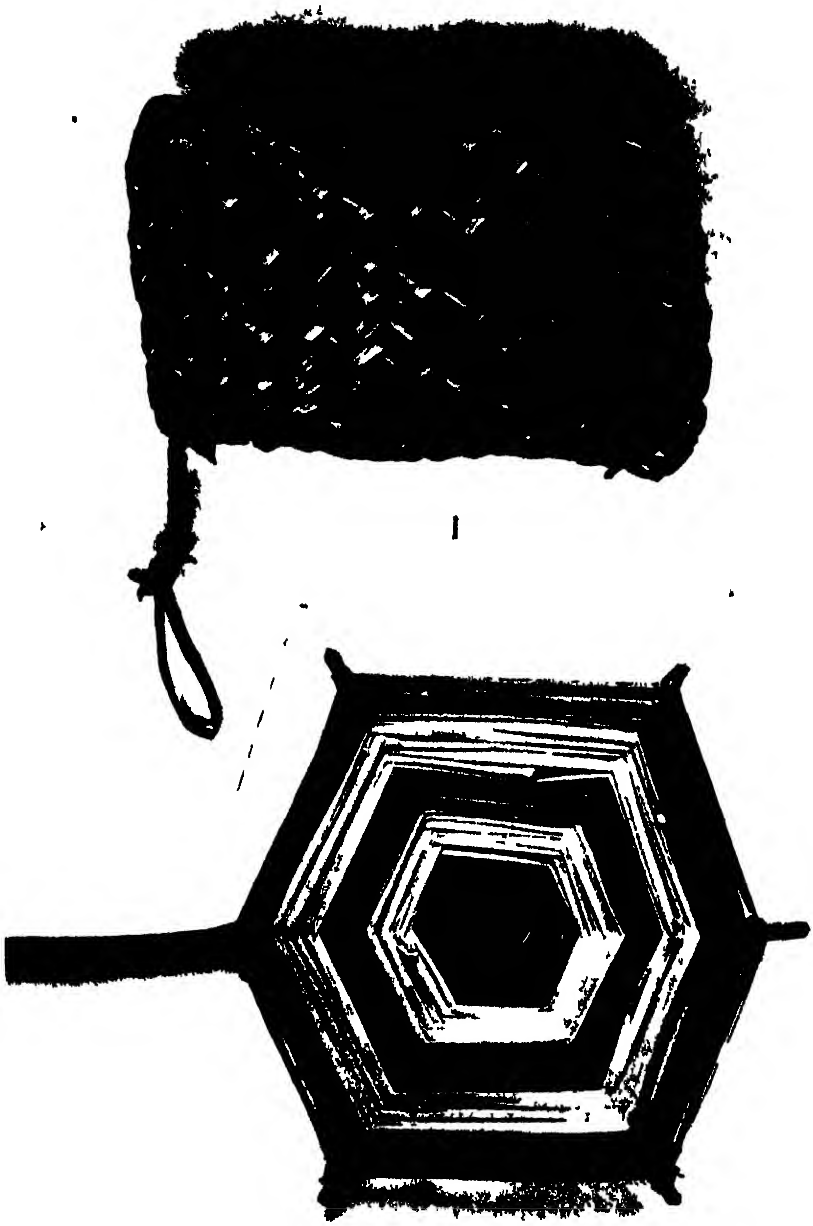
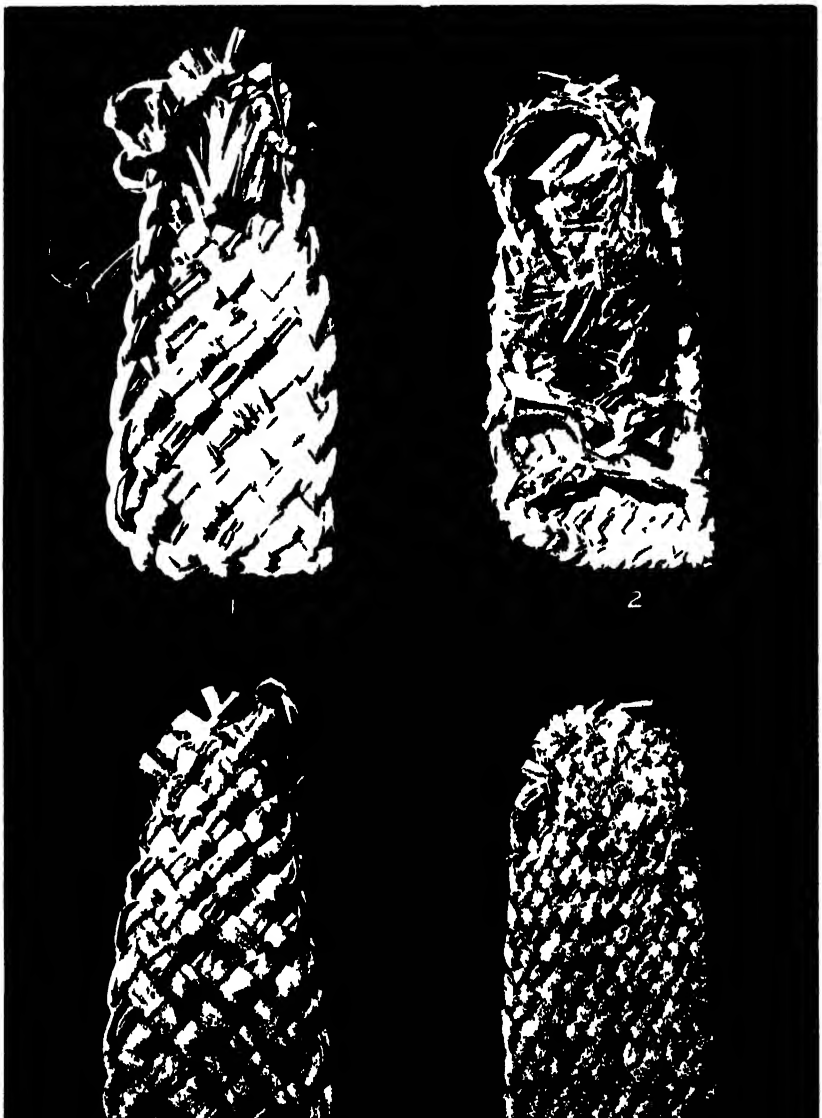


Fig 1 *Piupiu ahi* (fire fan) Fig. 2 —*Patungaro* (fly flap)



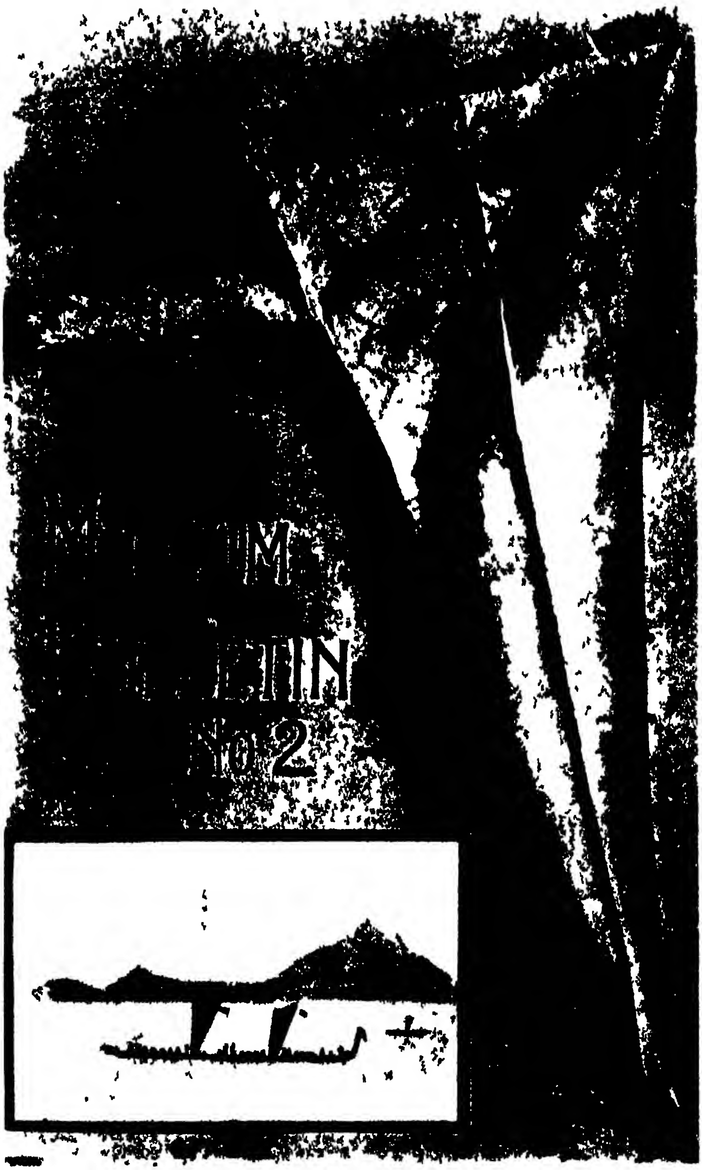
Paraerae (sandals). Upper surface of sandals for right foot.

Fig. 1.—Check stroke, *taki-tahi*; lacing strands turned back to show detail of heel; upper elements of double wefts twisted over knotted strand back on to upper surface of heel part; lower elements show cut-off ends projecting beyond heel margin.

Fig. 2.—Twilled two stroke, *torua*; lacing strands in position and tied.

Figs. 3, 4.—Under surface of figs. 1, 2.

Sandal in position: the heel band, three side loops, lacing across loops and the tie show clearly; the [illegible] strands are frayed through age.



Ra, or *mamaru* (sail) from *Museum Bulletin No. 2*

The butt ends are not specially scraped, though they show a tuft of fibre from the *takirikiri* process of tearing the strips off the butt end of the leaf. The strips are allowed to dry a little, so as to avoid subsequent shrinkage. The whole bundle of strips is divided into two equal parts. The strips composing one part are knotted together at their thin ends, corresponding to the narrower tip end of the leaf, with an overhand knot. The strips are then separated into three equal parts, and, commencing from the knot, are plaited in three-ply braid. As the strips increase in width the band naturally thickens and widens. The plaiting is continued for about 11 in., when the three equally divided parts of the other half of the strips are added, one to each ply. The strips are reversed, the wider butt ends of the added strips being plaited in first. The added strips materially increase the thickness of the band, until the butt ends of the first set are reached, when the band gradually tapers off until the tip ends of the second end are reached and finished off with an overhand knot. The total length of the band I am describing is 46 in. Its width in the middle is 2½ in. and thickness 1¼ in. The part of the band between the tapering 11 in. at either end maintained the fairly even width of 2¼ in., and therefore the business part of the band is roughly 2 ft. in length. It was thus necessary to have two or three bands to encircle the oven, the tapering ends, being too low, being overlapped by the wider parts of the neighbouring bands. (See Plate 36, fig. 3.)

These braided *paepae* lasted a long time, and were hung up in the cooking-houses after use. They make a strong serviceable band, but owing to their narrower width the food is more likely to flow over than with the wider-plaited bands. On the other hand, they save the trouble of seeking out fresh flax before cooking each meal.

5. FIRE-FANS: *PIUPIU AHI.*

Fans, which must have been well known to the Maori in Polynesia, were soon forgotten and discarded in the colder climate of New Zealand. So far as one can gather, there were no fans used for directing a current of air towards the heated face. The sole representative of the well-made and artistic fans of the various Polynesian islands was a rectangular strip of plaited flax used for fanning a smouldering fire into flame. To avoid the repeated use of the fire-plough, with its somewhat strenuous exertion, the coals of a fire which had completed its immediate work were covered over with ashes so as to keep them alive. To restart the fire the ashes were parted, and the coals, which had smouldered slowly, were fanned into a glow as the kindling-wood was added. The banking-up of fires was an ancient and important method of preserving a light, and is illustrated in the following incident. One of my tribal ancestors, who had been reduced to weakened circumstances owing to the untimely death of his six elder brothers and their warriors, was subjected to a series of annoyances by a neighbouring sub-tribe. This was done in order that he might be constrained to leave the district without an actual declaration of active hostilities. When he went inland, his previous day's catch of fish, hanging up to preserve, were surreptitiously removed. When he went afishing, his stacks of fern-root, drying in the sun, were similarly appropriated. The limit of forbearance was reached when the live coals of his banked-up fire were abstracted. The coals were not put out with water, as active signs of interference would have been noticed; but, like the fish and the fern-root, they simply disappeared—they faded away. The sole survivor of

powerful family, realizing his impotence, spake bitterly and said, "*Ko te moko ta kau i au; mehe ko te moko i a Rangi-nui-te-Ao, e mana ana te kohatu, e mana ana te tukituki*" ("Alas! the tattooing of my face was in vain; were it but the tattooing on the face of Rangi-nui-te-Ao, then the stone club and the stone pounder would be backed by the authority of power"). Rangi-nui-te-Ao was the eldest of the seven brothers. This saying reached the ears of Tukutahi and Rehetaia, the powerful kinsmen of the helpless one. Inquiries and explanations led to the advent of a war-party, which effectively—but that is another story.

The *ahi-ka-roa*, the fire that has been alight for a long period, is a well-known term in establishing claims to land. It takes its origin from the custom or necessity of not allowing the fire to become extinct.

Apart from the method of rekindling a cooking-fire, charcoal fires were the ordinary means of heating the *wharepuni*, or dwelling-houses. The lack of ventilation prohibited the use of wood, owing to the nuisance created by smoke. The charcoal as it burnt down was covered by a deposit of ash, which was usually gently waved off with the fire-fan ere a fresh supply of charcoal was added.

The necessity for a fire-fan was further occasioned by the general repugnance of the Maori to blowing a fire with the breath. This took its origin from the prohibitions imposed by the law of *tapu*. If a chief blew on an ordinary fire, the breath, coming as it did from his sacred or *tapu* head, impregnated the fire with *tapu* and prohibited its use for cooking purposes. Food is *noa*, or common, and at the opposite extreme to *tapu*, and food could not be cooked on such a fire. If cooked inadvertently, the *tapu* affected those who partook of it, and the act thus transgressed the chief's *tapu*. The act of cooking food on such a fire was also a direct insult to the chief, and it is probable that the abstaining from cooking was due not only to fear of the supernormal guardians of the chief's *tapu*, but also to fear of active human reprisals. Thus the principle of blowing a fire with the human breath was dangerous, and was avoided by using a mechanical contrivance, the fire-fan. In these degenerate socialistic days the fear of *tapu* has vanished to a great degree, and the fire-fan has lost its monopoly. Two generations ago, however, every old woman had her fire-fan, which, when not in use, was kept under the edge of a floor-mat flanking the fire.

The fire-fan is generically known as *piupiu ahi*. The many words used to express fanning a fire were also used for the fan. Such are *towhiriwhiri*, *kowhiuwhiu*, *powaiwai*, and *powhiri*. The technique of the fire-fan is quite simple. Ordinary wefts of green flax are plaited, usually with a twilled-two stroke, in the manner of a miniature floor-mat of the *taka* variety. The one figured in Plate 37, fig. 1, is 8¼ in. long by 5 in. wide. The beginning-edge may be done by plaiting the butt wefts with a three-ply braid as in the *taka* mat. The *kopetipeti* finish is often used with the *hiki* plait as well. In the fan figured, the beginning was simply commenced by interplaiting the wefts for a short distance and then using the *kopetipeti* finish to secure them. The last wefts of the finishing-border are sometimes continued into a braid to form a loop by which the fan may be hung up; though, as mentioned, it is usually kept under the edge of a floor-mat.

6. FLY-FLAPS: *PATUNGARO.*

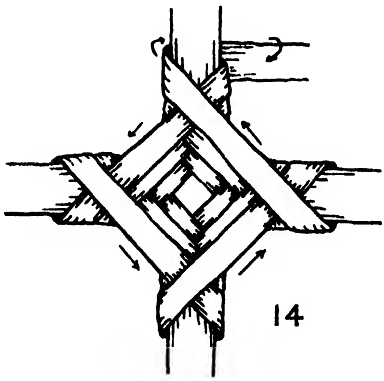
The fly-flap, or fly-whisk, of Polynesia again finds a modified representative in New Zealand. The *fuifui lago* of Niue and *fue* of Samoa are

made of braided sinnet, a number of strands being tied to a handle and the free ends left unplaited. They resemble the horse-hair fly-whisks used in Egypt. In many of the Pacific islands, Niue especially, swarms of flies similar to the house-fly frequent the highways and byways, and swarm round undefended human beings in myriads. In Niue it is rare to see Natives walking about in the daytime without leafy branches constantly in motion to prevent these pests from alighting on them. To a man with any feeling of pride in himself the fly-whisk is an indispensable part of his everyday equipment. In New Zealand the protection of the living from flies was unnecessary, and the fly-whisk of Polynesia disappeared. I have heard members of the Aupouri Tribe of the far North say that their high chiefs were so *tapu* that dire results took place if a fly that had alighted on their sacred heads subsequently alit on food. One man stated that to prevent such calamity attendants were careful to prevent flies from alighting on such chiefs. The immunity of the living Maori, however, was not shared by the dead. In olden times one of the weaknesses of the Maori was that of keeping their dead above ground for as long as possible: a too-hurried burial was looked upon as a disrespect to the dead. Grief must be allowed a considerable time to demonstrate its intensity. Even in these more enlightened days, owing to the desire of distant relatives or mourners to view the corpse, a good deal of trouble is sometimes experienced by the Department of Health in obtaining speedy burial in cases of death from infectious diseases. By-laws have had to be enacted under the Maori Councils Act to ensure burial in four days in the winter, three days in the summer, and twenty-four hours in the case of infectious disease. It can be understood, therefore, that in ancient times a corpse before being finally disposed of attracted more than the usual number of flies. To meet this the fly-flap, that had been discarded for the living, was retained or reinvented for the dead. Sinnet and horsehair not being available, and dressed flax-fibre causing more trouble than seemed necessary, the Maori form of fly-flap underwent a complete change. It has no connection with the fly-whisk of Polynesia except in part of its function.

The object was to attach to a handle a flat surface of sufficient area to ensure swatting a fly that had alighted on a corpse. As the appliance was only for the one corpse, and was not kept afterwards, no great care was taken in material selected or art displayed in the making. A thin rod 2 ft. to 3 ft. in length, of *manuka* or other wood, formed the handle. A short piece of similar wood from 5 in. to 6 in. long was placed across the long rod about 2½ in. to 3 in. from one end. This formed a cross with three equal limbs, the fourth long limb forming the handle. A strip of lightly scraped flax about ½ in. wide was then used to form the flat striking-surface of the flap. It was crossed over the middle of the front piece of wood, and then, working from this centre outwards, was wrapped in succession round each of the four limbs of the cross. Reference to fig. 14 will show that the flaxen strip is crossed over the anterior surface of the limb, wrapped completely round it, and crossed over itself on its way to the next limb. Thus the stroke used is a wrapped stroke identical with that used in the decorative panels of houses (6). As each turn of the strip follows the shortest distance between two limbs of the cross, it follows that the figure developed is a square set on an angle, and thus appearing somewhat lozenge-shaped. This stroke was continued until the strip reached the ends of the three short limbs of the cross, when the end was tied. As each turn between the limbs was made, the strip of flax overlapped the outer edge of the previous turn, and

so presented a close surface. The completed figure maintained its lozenge-shaped appearance from the long axis of the handle passing diagonally through opposite corners of the square. It is interesting to note that the name of the fly-flap, *patu ngaro*, is given to some of the lozenge motives in the decorative lattice-work of house-panels. The Ngati-Porou of the east coast called a fire-flap a *hauhau rungo*. Occasionally a strip of flax dyed black was alternated with the white to give a decorative effect. Occasionally, too, there might be two cross-pieces instead of one, this producing a six-sided figure. (See Plate 37, fig. 2.)

Though practically confined to use in connection with corpses, the fly-flap has on occasions been used for the destruction of flies in a living-room. Some years ago, when Maori political prisoners from Taranaki were confined in the Wellington gaol, the number of flies disturbed their slumbers in the summer mornings. Thirty men of the Ati Awa Tribe made fly-flaps and successfully conducted a campaign of extermination. The news of their



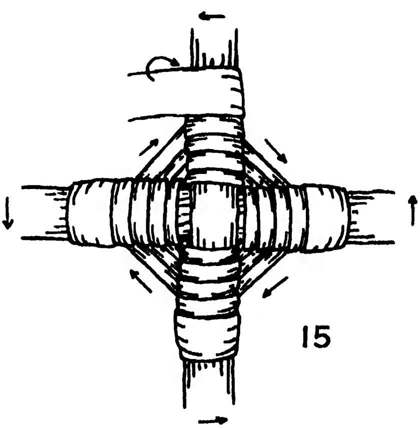


Fig. 14.—Fly-flap: front. Fig. 15.—Fly-flap: back.

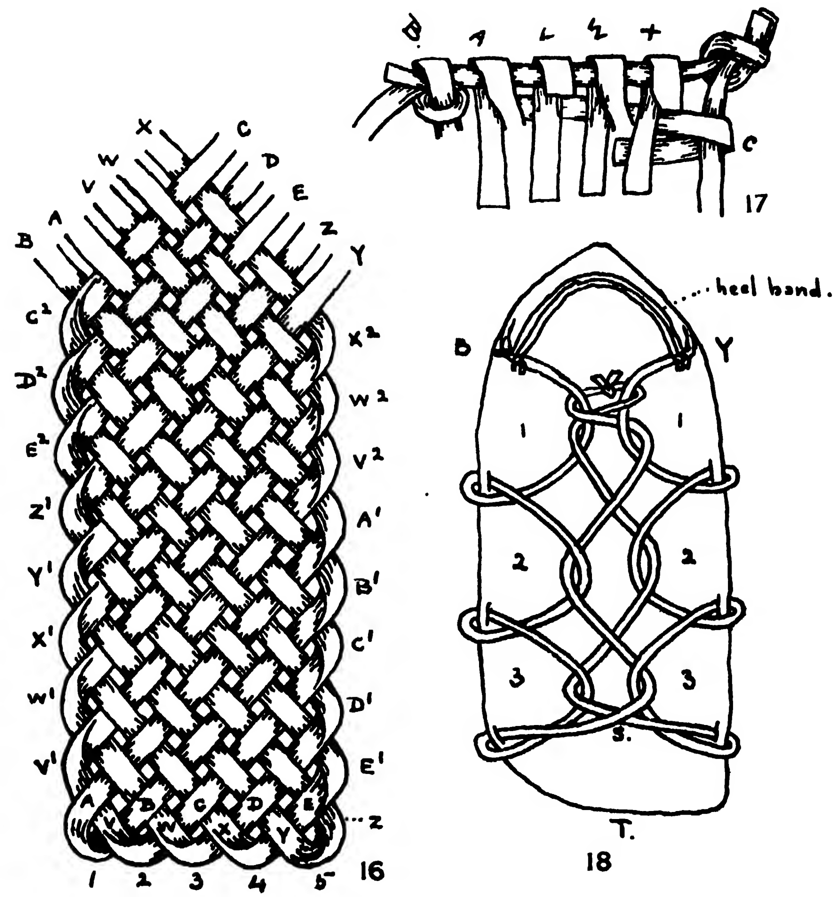
Fig. 15 shows that the flax strip crosses the posterior surface of the arms of the cross horizontally or vertically, whereas on the anterior surface it crosses diagonally.

success reaching the neighbouring Ngati-Ruanui Tribe, a formal invitation conducted with all the etiquette appertaining to ancient warfare was sent to the Ati Awa. The thirty warriors, fully armed, obeyed the summons, and conducted the attack so vigorously that in a short space the Ngati-Ruanui tribal prison-cells were utterly cleared of the enemy. Ceremonial speeches were then made by the indebted tribe, and a large (for a prison) quantity of tobacco handed over with due observances to the victorious war-party. It was one of these successful veterans who constructed the fly-flap above described. Thus the temporary incarceration of my own tribe has resulted in the recording of an ethnological item of some small interest.

Flat ornaments made like the fly-flap were used on the ends of the plumes (*hihi*) of a canoe. They were also called *patu ngaro*, from the origin of the motive. The same motive is also used in some fish-traps, such as the *torehe* and the *tutoko*. They were used as bait-rests, a strand of flax or fibre being passed over the bait and round the projecting arms of the cross to secure it in position. The Whanau Apanui Tribe, of the Bay of Plenty, term the bait-rest of the *torehe* trap a *pouraka*.

7. SANDALS: *PARAERAE.*

Sandals were plaited from flax, or the leaves of the *Cordyline australis.* They seem to have been quite common in the South Island. Skinner (7) mentions that on the Poutini coast they were also made of mountain-grass, and that in expeditions from five to twenty pairs were carried by each individual. They were quickly worn out in rough stony country or in swamps, and when a halt was made more were manufactured from whatever material was available. In the North Island the use was not so universal. The Whanganui and East Coast people know nothing of them,



Figs. 16–18.—Diagrammatic representation of sandal: 16, the sole: 17, half the heel; 18, the lacing.

and regard them with scepticism. In Taranaki, however, they were worn until fairly recently by old men at Parihaka. They say they were used to protect the feet from the frost as well as the rough stones on the beaches. They were also used in the Taupo and Moawhango districts, where they were termed *parekereke.* Best (3) states that in the Tuhoe country special ones were plaited from the *tumatakuru* shrub (*Aciphylla squarrosa*) for crossing the Huiarau Range. A rough kind of combined sandal and legging is named

tumatakuru after the plant *Aciphylla.* In the South Island the name *tumatakuru* is applied to the wild-irishman (*Discaria toumatou*—"matagowry"), the name for the various species of spaniard (*Aciphylla*) being *taramea.* In Tuhoeland, according to Best (3, p. 653), *Aciphylla squarrosa* is *tumatakuru*, *A. Colensoi* being *taramea.* Shortland (11, pp. 209–10) when journeying up the coast of Canterbury in January, 1844, used sandals, which he said were made of leaves of flax or *ti* (*Cordyline australis*), the latter being the tougher. The ordinary sandals were *paraerae;* a double-soled kind, called *torua*, were used on the stony beach, and lasted several days. "They no doubt," writes Shortland, "owed their invention to the necessity of protecting the feet from the snow, and the sharp prickles of the small shrub 'tumatakuru' (*Discaria toumatou* Raoul), which is very common on the plains, and often lies so much hidden in the grass, that you first become aware of its presence by your feet being wounded by it." In the interior of the plains the plant is a tree 14 ft. or more in height.

Mr. D. McKee Wright found two pairs of these sandals in a cave in the Upper Taieri, Otago, with other material proving that they were of old manufacture. Hamilton figures them in vol. 29 of the *Transactions of the New Zealand Institute.* Through the kindness of Mr. F. V. Knapp, of Nelson, in whose possession they now are, I have been able to figure them for this article. The wefts are double, and the thick butt ends of the blades are used as much as possible. One pair, plaited with a check stroke, *taki-tahi*, had not been used, and the flaxen strips for tying them on the feet were wound round the sandals and across the instep. They were 11 in. long, 4¾ in. across the toes, and narrowed down to 3½ in. across the instep and 3 in. across the heel. Fig. 16 is a diagrammatic representation of one, but reference to Plate 38 shows that by tightening the wefts the part that corresponds to the little toe is rounded off and so approaches more nearly the shape of the foot. The wefts are ¾ in. to ⅞ in. in width. Five long double strips are used, and these, by being bent in the middle, form ten wefts. The technique may be followed by referring to fig. 16. Commencing at the big toe, 1, the first strip is twisted on itself in the middle and runs diagonally from the big-toe corner towards the right to form two dextral wefts, A and B. The second strip, 2, has one part, V, passed through the loop of the first strip, above B and below A. It goes to the left and functions as the first sinistral weft. The other part, C, is twisted forward at right angles to V and runs parallel with A and B to act as the third dextral. The third strip, 3, has one part, W, passed over C, under B, and over A, thus continuing the check stroke and acting as the second sinistral. The other part, D, is twisted forward at right angles to W and runs parallel with C to form the fourth dextral. The fourth strip, 4. is treated in a similar way. The left portion, X, acts as the third sinistral, and continues the check by passing above D and B and under C and A. The right portion, E, runs parallel with D and completes the five dextrals. It will be observed that there are now five dextrals and only three sinistrals. This is due to the first strip, 1, having been twisted round so that both parts run parallel to one another to form two dextrals. The fifth strip, 5, is now treated in a similar manner to the first, only in the opposite direction. The left portion, Y, carries on as the fourth sinistral by passing over E, C, and A, and under D and B. As the appropriate width of the sandal has been reached, the remaining portion, Z, must be twisted back into the body of the article. It is therefore twisted back to run under E C and A, and over D and B, and to lie parallel with its first limb as

the fifth sinistral. Thus is the tale completed. The strips 1 and 5, by being doubled round, lock the wefts in position on being tightened. They not only mark the ends of the toe-border, but commence the two side borders. Thus, on the left side, the first weft to project beyond the side edge commenced by A is the first sinistral weft, V. This is now twisted back into the work at V^1 to function as a dextral. To continue the check stroke it must pass above the first crossing-weft that it meets—namely, W. The rest follows automatically. The next left-hand weft to emerge beyond the border thus defined is W, and it is twisted back at W^1. On the right-hand border the first weft to emerge beyond the defining weft Z is the last dextral, E. This is twisted back at right angles at E^1, passes under the crossing-weft D to continue the check, and carries on as the sinistral. So the plaiting proceeds, wefts being turned back as they reach the side borders. Thus V, which started as a sinistral weft, by the turn at V^1 becomes a dextral, and at V^2 on the opposite side becomes a sinistral again. It will be noticed that the turns at the edges are made with a backward turn on the left and with a forward turn on the right. It is immaterial which way the turn is made so long as a similar one is made on each border for the sake of appearance. As the plaiting continues the wefts are drawn together more tightly, so as to narrow the sandal towards the instep and the heel. After eight turns at either border the sandal is long enough. Without any further twists at the side, the crossing-wefts are interlaced to continue the check stroke, and the plaiting ends at the point made by the crossing of the two marginal wefts, C and X. Five wefts are left on either side.

The sole being completed, the fastenings are attached in the following manner: Two strong strips of flax are knotted together at the butt ends with an overhand knot. The knot is laid upon the apex where C and X cross in fig. 16. The two strips are diverged so as to lie upon the marginal wefts, C and X (fig. 16). The wefts that entered into the construction of the sole have been double wefts throughout, one element lying upon the other. In the following procedure the upper elements alone are used, the lower elements being disregarded for the time being. The left marginal weft, C, is crossed over the right strip of flax and brought round and under it back on to the upper surface of the sole, as shown in fig. 17. The right marginal weft, X, is treated in a similar manner with regard to the left strip of flax. This fixes the point of the heel. Note that no half-hitches or knots are used. Following down the five projecting wefts on the left, W, V, and A are treated in the same way as X. B, the last of the series, is simply tied to the strip with an overhand knot as in fig. 17. Referring to fig. 16, the wefts D, E, and Z on the right are treated in the same manner as C; and Y, being the last of the series, is tied to the right strip with an overhand knot. The heel-margin is thus defined, and the wefts fixed. The lower elements of the ten wefts are simply cut off close to where they emerge from the last crossing-weft. Fig. 17 is purely diagrammatical. Plate 38, fig. 1, shows the weft-ends close together and projecting in over the heel-area for about 2 in. This side, done last, naturally forms the upper layer.

To complete the heel part, two or three strips of flax are tied to the two flaxen strips at about 1 in. above the knots at B and Y. They are tied with simple overhand knots on either side, and are about 4 in. in length. The ends of the cross-strips are tied close together, and form a heel-band to secure the heel part by passing across the tendo Achillis above the point of the heel. (See fig. 18.)

The lacing arrangements over the foot were admirably shown in the second pair of sandals in Mr. Knapp's collection. In these the twill stroke, *torua*, had been used, and they had been worn, as is proved by the condition of the under-surface of the sole. The lacing-strips were in actual position, with the ends tied. Plate 39 shows one of the sandals in position on the foot. The foot, being small, was slipped in without disarranging or untying the lacing-strips. Fig. 18 shows the technique. It will be seen that the two long flaxen strips which helped to fix the upper layer of heel-wefts, and to which the heel-band was attached, are carried down on either side-border in three loops formed by passing the strips through these weft-turns at the edges, the third loop being the strip next to the toe-border, The strips are now simply interlaced through the loop on either side, and tied together in front of the ankle as shown in fig. 18 and Plate 39. At times a short strip of flax is passed through the middle of the toe-border at T and tied round the two lacing-strips where they cross to the third loop at S. The loop and lacing-strips being continuous, the former can be adjusted to any size of foot.

Besides *paraerae* and *parekereke*, Williams gives *parahirahi* as a sandal made of flax. Hamilton (8) states that there were three kinds of sandals made in the South Island. One kind was made of a single layer of plaited flax-leaves, and was called *paraerae hou*, or *kuara*, or *parekereke*. Both *paraerae* and *parekereke* are North Island names for sandals in general, whether made of flax or *ti* (*Cordyline*). *Paraerae hou* seems to me to mean sandals made from fresh leaves, whether of flax or *ti*. His second kind, named *takitaki*, seems to be a misprint for *takitahi*. *Takitahi* is the North Island term for the check stroke, and is applied to a sandal to indicate the technique employed. His third kind, *torua*, is also used in the North to indicate the stroke used--viz., a twilled two; but according to Shortland, quoted above, it may have been the name in the South for the sandal with double sole.

Best mentions that combined leggings and sandals were made. Besides *tumatakuru*. the names *rohe* and *papari* are given by him for this article. He also mentions toe-caps, called *paenaena*, and leggings, called *parengarenga*. Of their technique I have no knowledge.

Sandals and shoes made of narrower white wefts and of dressed fibre are to be seen in our museums, but they must be regarded as modifications originating in post-European times.

8. SAILS: *RA*, OR *MAMARU*.

Though plaited sails were used in pre-European times, and are described by Forster in vol. i of "Cook's Voyages," there are no specimens in New Zealand to enable us to describe the technique. Brigham, in his paper on mat and basket weaving, quoting from Mr. Stokes's essay on the "Mat Sails of the Pacific," gives a little detail of the sails made in Micronesia. The Marshall-Islanders made them of pandanus-leaf. A lap-board of bread-fruit wood was used. Long strips of sail-mat were plaited, and then strips were placed together with the edges overlapping. These were sewn together with coconut-fibre. The strip figured by him is 4·7 in. wide, and the width of the wefts from $\frac{3}{32}$ in. to $\frac{1}{8}$ in. The sail was twice as heavy as an ordinary mat and a little heavier than canvas. A few strands of dyed hibiscus-fibre were worked in by overlaid plaiting to run diagonally across the strip of matting. The picture in Brigham's paper shows that a twilled-two stroke was used. Stokes records that the Hawaiian sail was

made in strips, but that of Tahiti seems to have been composed of several large mats sewn together.

Fortunately a Maori sail survives in the British Museum, and has been figured by Hamilton. (See Plate 40.) It is triangular, with the base upwards, and has loops for the mast and sprit. From the posterior edge near the top a flag-like appendage juts out. The edges of this and of the top of the sail are decorated with tufts of feathers. Double zigzag coloured lines run vertically down the sail. Hamilton says that the material is either flax or *kiekie*. From the narrow width of the wefts as shown in the photograph (Plate 40), it is evident that the material is one of the two mentioned by Hamilton. Edge-Partington figures the same sail in his *Ethnological Album*, 3rd series, p. 162, and gives the dimensions as follows: Length, 14 ft.; width at top, 6 ft. 4 in.; width at bottom, 12 in.; length of play, 3 ft. 6 in.; width of play, 8 in. The width at the top, 6 ft. 4 in., is wider than the usual section of a floor-mat, and it is probable that in the upper part there is a join. The line running down the middle looks like a crease due to folding. Close-up photographs of the sail should be obtained from the British Museum and replicas plaited for our own museums. This could be done quite easily. Sails have been so long out of date that the possibility of obtaining such a copy of an authentic old-time sail should not be neglected. The only authentic copies that our museums possess of the *kotaha* (throwing-stick) were made and carved by Anaha, of Rotorua, from measurements and casts kindly supplied by Edge-Partington from those in the British Museum. The one vestige of information concerning anything approaching the old-time sail that I could obtain was an incident narrated to me by Paratene Ngata, of Waiapu. During the Hauhau war on the east coast in 1865 the friendly Maori captured seven canoes at Tokomaru. Using ordinary rectangular floor-mats of the *porera* class, they rigged them up like main-sails, but with a Maori diagonal sprit, or *titoko*, instead of the pakeha lower boom. A rope was tied to the lower posterior corner. With mats hoisted, this curious fleet successfully sailed to Tuparoa.

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To Mr. J. McDonald, of the Dominion Museum, are due most of the plates, and the figures of the *tipare;* Mr. H. Hamilton supplied photographs of belts, fly-flap, &c. From Mr. Best's article on "The Art of the *Whare Pora*" much has been learned, and free use has been made of its information. To many women of my own race in the east and the west I owe thanks for their unfailing patience and readiness to supply information and demonstrate techniqe. The women of my own tribe were at first loth to encourage me in what they considered was not man's work.

In conclusion, this and the former article make no pretension to having exhausted the art of plaiting. There are tribal differences in commencing, joining, and finishing floor-mats, and quite a number of different varieties of baskets and minor articles yet to be described. They will receive attention as opportunity occurs. I hope, however, that sufficient of the Maori technique of plaiting has been recorded to form a basis for comparison with the same art in Polynesia and along the route the Polynesians travelled in the past.

ERRATUM.

In the article on "Maori Plaited Basketry and Plaitwork," *Trans. N.Z. Inst.*, vol. 54, p. 714, under fig. 1, instead of "Commencement of weaving a *taka* mat," read, "Commencement of plaiting a *taka* mat . . . ."

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The Passing of the Maori.

By Te Rangi Hiroa (P. H. Buck), D.S.O., M.D.

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Introductory.

"The passing of the Maori." These words have a sad and mournful sound. They almost convey the idea that in order to do justice to the subject we should bind our brows with wreaths of *kawakawa* leaves, lacerate our flesh with obsidian flakes, and raise the wail of the *tangi*, for "a race that's speeding sadly onward to oblivion." Such seems to have been the attitude of most writers in the past.

In 1881 Dr. Newman (1, p. 477) stated: "Taking all things into consideration, the disappearance of the race is scarcely subject for much regret. They are dying out in a quick, easy way, and are being supplanted by a superior race." Thus he relegates us to the Shades, and we cease to be as important as the carvings our brains designed and our hands executed.

In 1884 Sir Walter Buller (2), in speaking before the Wellington Philosophical Society, said that it was a "fact that the Maori race was dying out very rapidly; that, in all probability, five and twenty years hence there would only be a remnant left." He quotes Dr. Featherston as saying in 1856, "The Maoris are dying out, and nothing can save them. Our plain duty, as good, compassionate colonists, is to smooth down their dying pillow. Then history will have nothing to reproach us with."

In 1896 (3) and 1902 (4) Hill struck a less pessimistic note by enumerating various proposals by which rapid extinction might be retarded.

In a paper read before this Institute in 1907, Archdeacon Walsh (5), after ably summing up the exterminating factors introduced by civilization, sounded our requiem in a more soothing and sympathetic manner, in keeping with his cloth. He said: "The Maori has lost heart and abandoned hope. It [the race] is sick unto death, and is already potentially dead." He quotes von Hochstetter as observing, in 1865, "The Maoris . . .

look forward with a fatal resignation to the destiny of the final extinction of their race. They themselves say, 'As clover killed the fern, and the European dog the Maori dog, as the Maori rat was destroyed by the *pakeha* rat, so our people also will be gradually supplanted and exterminated by the Europeans.'"

From Featherston in 1856 to Walsh in 1907 is half a century. The cumulative experience and study of half a century led the writers quoted above to see the Maori race facing nothing but rapid extinction. In view of the fact that these writers gathered the procurable data of their day and subjected them to careful analysis, their conclusions must be treated with respect. The Maori race should show more active signs of becoming extinct; yet in spite of the hopeless outlook expressed to von Hochstetter by the victims of the Taranaki War, the present generation refuses to comply with the picturesque but illogical simile of following the way of the vanished Maori rat and the extinct Maori dog. They do not appear to belong to the same class of mammal. The native fern does not seem to be tamely giving way to the European clover. In this respect the Maori has more in common with the flora than with the fauna.

The quick and easy death prescribed by Dr. Newman has not been availed of as he led us to expect. Sir Walter Buller's twenty-five years grace expired in 1909. The race that Archdeacon Walsh said was already potentially dead in 1907 should be literally so in 1922.

Of the five papers quoted above, four have been published in the *Transactions* of this Institute, whilst the fifth was read before the Wellington Philosophical Society. Since the last address was delivered fifteen years have elapsed. It is therefore fitting that the present condition of the Maori race should be reviewed, to see how far the sad prognosis of the past has been borne out by the facts of the present.

POPULATION.

Cook estimated the Maori population as 100,000. As pointed out by various writers, this estimate could have been only a very rough guess, formed from the coastal tribes that he saw.

The west coast of the North Island he never explored. Northern Taranaki, from the evidence afforded by the denseness of the terraced hills, must have supported a very large population. Whakatane, the Waimana Valley, and the Tauranga district show innumerable signs of close occupation. In the Oruru Valley, in the north, the forts were so close together that they were termed *Oruru pa karangatahi* (Oruru with the forts aroused by one call). Consider the huge garrisons that must have been required to man the crater-forts near Pakaraka and Ohaeawai, in the Bay of Islands, and the many terraces extending over acres of ground in the Tamaki forts, on Mount Eden, and One Tree Hill. If the present Maori population of Orakei and the villages about Onehunga and Mangere were gathered to man the reconstructed parapets of Maunga-kiekie, how many terraces would they occupy? And yet there were other forts in this same district occupied at the same time. Furthermore, the population was not confined to the coast-line and its immediate vicinity. Occupation depended on food-supplies, and, incidentally, of course, on the ability to hold the territory producing them. The larger rivers and inland lakes produced fish in abundance in their due seasons. This supply was not confined to eels, but smaller fish, not considered by Europeans, made up for their lack of size by their quantity.

Lakes Rotorua and Taupo have no eels, yet the fresh-water fish furnished supplies throughout the year, sufficient being preserved to last between the seasons. The forests teemed with birds, which in turn had their seasons. Hence there were large tribes settled along the courses of the larger rivers, such as the Waikato, Waipa, Whanganui, Waitara, and others, whilst the larger lakes of Rotorua, Rotoiti, Taupo, and Waikaremoana supported large numbers upon their shores. As the forest is being cleared away, signs of terraced occupation are being revealed in inland parts concerning which traditional records are meagre or non-existent. Though many of these sites may have been temporary abiding-places for fishing and hunting purposes, and others again have not been continuously occupied, after making liberal allowances the signs of occupation point to the existence of a large population in pre-European days.

Some rough idea may be formed by comparing these past traces of occupation with the actual villages occupied in a district at the present time. Compare the numbers living at Orakei and Mangere with the number required to man either Maunga-kiekie (One Tree Hill) or Maungawhau (Mount Eden). This having been done, remember that there are none left to man some of the other forts that were occupied at the same time. The fighting Ngati-Tama, who manned and held the many strongholds of that stormy strip of Taranaki coast between the Mokau River and the White Cliffs, the "gateway of the west," have dwindled down to a single scattered village of barely fifty souls; yet in their day they not only withstood the ceaseless onslaughts of the great Maniapoto and Waikato tribes, but conducted victorious campaigns to the north and to the south. Some of them live in conquered country to the south, but where are the people whom they dispossessed? North and south, east and west, the same sad comparisons hold. There are stretches of coast with many magnificent *pa*, girt with fosses and rising strong and impressive with tier on tier of terraces, but with no modern villages nestling at their bases, and no living descendants of the old-time military engineers to recite the history of ancestral achievement. What proportion, then, shall we say existed in the numbers of the men of the past to the men of the present? Were they four times as many? They were at least that. Were they ten times as many? It does not seem improbable. With a present basis of 50,000 this would mean a pre-European population of from 200,000 to 500,000. We shall never know.

Whether the expressed view of some European writers that the diminution of the population had commenced before the advent of their own recent ancestors is in the nature of an excuse or not, we certainly know that the diminution was considerably accelerated after their arrival. The introduction of firearms by civilized traders altered the whole aspect of Maori warfare. What might almost be termed a manly physical exercise degenerated into killing expeditions to avenge old defeats and to acquire new territory. There were never such numbers slain of old as occurred after the acquisition of guns in the first quarter of the nineteenth century.

Archdeacon Walsh estimates that in the campaigns of Hongi Hika, Te Wherowhero, Te Waharoa, and Te Rauparaha, fully one-half of the population were killed. The introduction of epidemic and venereal diseases, and the abuse and misuse of European alcohol, foods, and clothing, all played their part in the decimation of the race. Influenced by the above causes, there was an added infant mortality. To aggravate the introduced wastage of Maori life were the unnecessary European wars of the "forties"

and "sixties." The wonder is that extinction was still being argued about in 1907.

In the following table the figures for the earlier years are estimates. The lowest ebb appears to have been reached in 1871, with another serious drop in 1896.

Table 1.—Population.

Authority.	Year.	Population.	Increase or Decrease.
Captain Cook	1769-74	100,000 (400,000)	
Nicholas	1814	150,000	
Rev. W. Williams (estimate)	1835	200,000 (120,000)	
Estimate	1840	114,000	
Governor Grey	1849	120,000	
Mr. McLean	1853	60,000	
Judge Fenton	1858	55,970	
Estimate	1867	38,540	
"	1871	37,520	
Colonial Government	1874	45,470	
" .. .	1891	41,993	
" . ..	1896	39,854	
"	1901	43,101	
Colonial Government (proper census) .	1906	47,731	*In.* 4,630
" " ..	1911	49,844	*In.* 2,113
" " ..	1916	49,776	*Dec.* 68
" " ..	1921	52,751	*In.* 2,975

Sir Walter Buller, when he made his prognosis in 1884, estimated the population at the low figure of 30,000. Twenty-five years later what should have been a remnant had reached the healthy figures of over 48,000. Archdeacon Walsh held that no reliance could be placed in the figures until the census of 1906. Here proper house-to-house visits were made by properly qualified enumerators, and the assistance of intelligent and trustworthy Maori with local knowledge was obtained. He considered that previous rises in population were due to inaccuracy of returns. He was so sure of the accuracy of the 1906 census that he further stated, in 1907, " Finality has now been reached, and the next census will show that the Maori population, instead of increasing, has been diminishing all the time, and that if the present rate of declension continues it must soon reach the vanishing-point." The next census, in 1911, taken by the same system which gained the Archdeacon's confidence, showed an increase of 2,113. The census of 1916 showed a falling-off of 68; but when it is remembered that hundreds of Maori troops were out on war service it will be seen that the decrease was not real. The next census, in 1921, showed an increase of 2,975. This increase is the more meritorious when it is remembered that, during the period it covered, the influenza epidemic of 1918 carried off over 1,000 victims. Thus, since Archdeacon Walsh said sixteen years ago that finality had been reached, there has been an actual increase of 5,020; and his vanishing-point has, we hope, been deferred for ever as far as extinction is concerned.

Increased Percentage of the Young.

We are apt to think that, as the older type of Maori passes away, so the race is decreasing, and the census increase is not real. There can be no doubt that large villages, populous within the memory of people of fifty years of age, have diminished in size and population. Whilst the decrease has in some cases continued up to the present time, in a majority of cases the increase in the last twenty years has been real. Through individualization of land the communistic village life is being broken up, and settlements have a scattered and sparse appearance as compared with the past. It is only when the tribes rally to the village meeting-house for some tribal object that a real idea can be formed of the numbers that are scattered on individual holdings. The increase in the number of children is shown by the increased problem of accommodation in Native schools. The following table shows the steady increase that has been taking place in the percentage of children in the whole population :—

Table 2.—Maori Population under Fifteen Years.

Year.	Population.	Percentage of Total Population.
1891	14,251	34·1
1896	14,248	35·7
1901	16,082	37·3
1906	18,417	38·6
1911	19,902	40·0
1916	20,536	41·3
1921	21,071	40·0

The Staying of Extinction.

In the confusion that followed the clash of two cultures, the Maori of the early nineteenth century was unable to distinguish the good from the evil in the two systems.

By adopting European weapons, food, and clothing, and becoming Christianized, he himself voluntarily commenced the disintegration of his own system of culture. No neolithic people could in one or two generations adopt and assimilate European culture in its best features. The Maori was further retarded by the fact that the culture introduced by many of the early trading and whaling vessels was, to say the least of it, not of a high standard. The influence of so many escaped convicts from Australia also retarded the efforts of the early missionaries. With so much to contend against, the Maori had to pay a heavy toll of life, and it is no wonder that the serious reduction in the number of the population should have made people think that the extinction of the race was close at hand.

The present increase of the race is due to the gradual elimination of the factors that caused decay. The first great change was the cessation of intertribal warfare with European weapons. The main cause of this cessation was the acceptance of Christianity. Defeated tribes who had subsequently acquired guns and were organizing for the day of vengeance accepted the teaching of peace and good will and laid aside their arms and thoughts of revenge. It must always remain a matter for regret that this peace should have been ruptured between the pakeha and the Maori in the " forties " and the " sixties," through lack of full appreciation of more pacific ways of dealing with the warlike Maori. More lives were lost, and

progress received such a shock that in some districts the evil effects still linger.

Though the guns and tomahawks were laid aside at a fairly early period, the effects of other evils continued for a longer time. Venereal diseases that were introduced by the crews of the early traders and whalers had their dying fires revived by the soldiers of the "sixties." I have learned on reputable authority that seventeen Maori women captured by white troops at the fall of one of the Waikato forts, on their liberation spread the disease amongst their people. The disease died out after working its havoc on the fertility of the race. Any serious recrudescence that might have occurred as the effect of helping to share the "white man's burden" during the Great War has, owing to modern methods and treatment, been arrested

Epidemic diseases that claimed so many in the past are no longer allowed to go unchecked. The prevention of disease by the organization of a special Department of Health has been of comparatively recent origin amongst the Europeans. In the benefits of such measures the Maori has shared to a material degree. The reorganization of Maori Health Councils, the appointment of Native Health Nurses and Sanitary Inspectors, and the setting-up of a Division of Maori Hygiene in the Department of Health have all had their effect in lowering the heavy mortality due to epidemic diseases. When we consider the mortality still caused by typhoid fever, we shudder to think of the days when it went unchecked, and *tangi* after *tangi*, in lamentation of the dead, spread the scourge from village to village. Medical Officers of Health and Hospital Boards keep a wary eye upon their districts, and the Maori people as a whole no longer accept disease and death with fatal resignation. In the last year or so, in districts where typhoid has occurred, over 2,000 inoculations against the disease have been made. The *Tokotoko rangi* ("Spear from heaven that sweeps away food and man"), that the ancient poet Turaukawa lamented over, no longer makes thrusts that go unparried.

Sanitation has made great advances. The simple but efficacious form of latrine that Rupe first instituted in the home of the god Rehua in the tenth heaven, copied by succeeding generations in the hill-forts of old, and abandoned with so much of good in the old culture, is being restored in its modern form in a modern environment. Water-supplies are protected, and modern systems installed. Ventilation, which as applied to communal meeting-houses was bitterly opposed twenty years ago, is now treated as a matter of course. Model by-laws are administered by Village Committees acting under the authority of Maori Health Councils. *Tangi*, *hui*, and such gatherings are conducted under sanitary rules, and avoid the disasters of the past.

Maori communal life is disintregating. Each generation has added something of European culture, and the old order changes, giving place to new. The thatched house with earthen floor is now, because of its rarity, a thing of ethnological interest. No longer is a group of small huts clustered round a meeting-house typical of a Maori village. Individualization of land and European needs are dispersing the families to their separate holdings. In many places the tribal meeting-house stands alone, or flanked by a solitary cooking-house, patiently waiting until a death or some object of great moment shall for a brief period draw its people together beneath its sheltering roof. Visiting ethnologists have asked me to take them to some typical Maori village where they would see something of the old Maori life, but I am unable to comply. The time was when I

could send a message to the chief of the village to assemble his people in the daytime—but not now: they are too busy attending to their farms or labouring to obtain a livelihood, and cannot afford to waste a day. Meetings must be held at night, and sufficient notice must be given to inform the scattered households. Then, when the discussion is over, instead of reclining in their rugs and telling tales of ancient days till dewy morn, they pick up their belongings and depart for their homes, for the coming day has its duties. This is as it should be.

Many people express the opinion that it is a pity that the old Maori *haka* (war-dances) and *poi* dances are being lost. In the same breath they say that the Maori must work his land and live like Europeans. The two are incompatible. The *haka* and the various dances were the amusements of a people living together and spending their evenings in a communal meeting-house. The Maori is adapting himself to changed circumstances, to a changed environment. The dirge of the lament and the rhythm of the dance will disappear with the communism that brought them into life. It is a pity from the point of view of sentiment, but sentiment alone will not provide for man's material welfare.

In the changes that have been taking place, the misunderstandings about food and clothing also have gradually been dispersed. Many of the old Maori foods, that were once a necessity, are now prepared only as a luxury on special occasions. European foods, in the orthodox combinations and methods of preparation, are now the ordinary fare of every household. The once universal earth-oven is used only on special occasions. Even at some of the large gatherings, steam generated by traction-engines is used instead of the heated stones of the past. European clothing is now misunderstood by the Maori no more than by the average European.

To see old Maori men of the present day changing into pyjamas ere ensconcing themselves between clean sheets is to realize the significance of the change they have undergone on their not long, if arduous, road of modern progress. All down the changing years the things that appeared impossible to one protesting generation of Maori were advanced a step nearer by the very ones who protested, and made possible for the generation following. The Maori who fought unsuccessfully against European troops in the wars of the "sixties" saw his hopes blighted and his visions of a Maori world crumble into ruins about him. He told von Hochstetter that the Maori would become extinct like the New Zealand fauna. Hochstetter and others believed him. The Maori of the present day, who fought side by side with the descendants of his former enemies on the fields of Gallipoli, France, and Belgium, fought for the honour of a common home and the saving of the new culture which he has adopted as his own. His horizon has expanded, and he realizes even more than a goodly number of the people of England what the British Empire really means. The nightmare visions of the past have been thrown off like a frayed flaxen cloak, and the unfettered Maori of to-day with self-reliance looks confidently forth into the future.

At the time Featherston, von Hochstetter, Newman, and Buller wrote they were probably justified in their doleful outlook. Hill enumerated various proposals, most of which have come to be adopted. The cumulative effects resulting in recovery were not so obvious to Walsh in 1907 as they are now. There was a tendency in the past to attribute the Maori decrease in population to an implied law that all dark-skinned races die out after contact with civilization. The Maori was regarded as inheriting extinction

because it was overwhelming other branches of the Polynesian race to which he belonged. Marett (6) points out that evolution is influenced by race, environment, and culture. He says: "Life evolves—that is to say, changes—by being handed on from certain forms to certain other forms, and a partial rigidity marks the process together with a partial plasticity. There is a stiffening, so to speak, that keeps the life-force, up to a point, true to its old direction, though short of that limit it is free to take a new line of its own. Race, then, stands for the stiffening in the evolutionary process. Just up to what point it goes in any given case we probably can never quite tell." It was this stiffening or partial rigidity in the evolutionary process, termed "race," that was to doom the Maori to extinction. The element of partial plasticity in the evolutionary process has not had sufficient weight attached to it as an avenue of escape for the Maori. It is this "superadded measure of plasticity, which has to be treated as something apart from the racial factor," that responds to the effects of environment and culture. As the environment has been changing, so the Maori, whilst maintaining his race, has been changing with it. To compare him with the present-day Polynesian of the tropics is unfair to the Polynesian.

Though the Maori is still of the same race, the plastic part of him has been subjected for over five centuries to a changed environment. Five centuries in a temperate climate toughened his constitution, sharpened his mentality, and altered his material culture. The islanders, with their open houses, scanty *tapa* clothing, and food without labour, were left far behind the Maori. The sea-roads to Hawaiki were closed down for ever. Warmer houses were built, weaving was invented, the cultivation of the *kumara* and the *taro* demanded more onerous care. The working of large forest-trees for buildings and canoes, the excavation of fossed and palisaded forts, and the numerous changed conditions induced by a more vigorous climate, caused him to shed the indolence of the tropics.

A more vigorous and virile people was bred, and when conditions were rudely changed with the nineteenth century the Maori was in a better condition to survive extinction than his more easy-going kinsman in Polynesia. As his material environment has changed in New Zealand, the Maori has strewn the century path with the thousands of his dead; but generation by generation the measure of plasticity has reacted little by little, until now the survivors have weathered the storm of extinction. In like manner the introduced culture has gradually been assimilated through necessity, association, and the teaching of schools. Better housing, regular work, a settled source of income, with regular meals, are resulting in an improved material environment for the family, which in turn provides a better prenatal environment for succeeding generations.

Dr. Rivers (7), in discussing the depopulation of Melanesia, assigns the greatest factor in the nearing extinction of some of these people to a psychological cause in the lack of the incentive to live. We know that the Polynesian can resign himself to die for no organic cause. The Maori in the past has been no exception. We have seen that some of the older generations, after the failure of military and religious attempts to restore the *mana* and power of the old-time regime, have prophesied early extinction, and had no hope in life. Fortunately, they produced offspring, and the healing hand of time has effaced such destructive pessimism. The Maori has a happy disposition, and his sense of humour has saved him from undue depression. In these days he has his amusements and manly

games, his hopes and aspirations, and every desire to prolong life. It was his sense of humour and his happy disposition that made him such a good soldier. He reacted less to the depressing conditions of European warfare than most of his white comrades, and there could be no greater test.

Proportion of Sexes.

When the number of males exceeds the number of females to an extensive degree it is looked upon as a very important factor leading to the disappearance of a race. Newman pointed out the great preponderance of males in the Maori population, and quoted Judge Fenton's figures for 1859, and those of the census of 1881. I have reduced these figures to females per 1,000 males, and added the European figures, in the following table:—

Table 3.—Females per 1,000 Males.

Year	Maori.	European.
1859 (Fenton)	766	.
1881	809	..
1891	832	883
1901	866	903
1906	869	887
1911	882	896
1916 (war-time census)	919	993
1921	890	959

It will be seen that since Newman's figures there has been a steady increase in the proportion of females. The 1916 census must be disregarded, as there were so many males out of the country on war-service.

From the data compiled with the kind assistance of Native-school teachers, the following result was arrived at:—

Number of Native schools	102
Number of pupils with Native blood	4,549
Females per 1,000 males	921

If we may take this as an indication of the proportion in the rising generation, it will be seen that the improvement is being steadily continued, and the menace of speedy extinction from the undue proportion of males is steadily being effaced. The change from 766 per 1,000 in 1859, to 890 in 1921, and 921 amongst the children in 1922, is one that is of the greatest importance.

Absorption of the Race.

Though we have pointed out that the theory of rapid extinction has been disproved by the increasing population shown by the latest census returns, it does not follow that the Maori will continue to exist as a distinct race for an indefinite period. The anthropological study of races teaches us that where a people survive extinction and at the same time are not able to maintain a certain amount of isolation they become merged in the general population. Dr. E. B. Tyler, in speaking of the unity of mankind, says, "All human races, no matter form or colour, appear capable of intermarrying and forming crossed races." In historic times, mixture of race is the rule, whilst racial purity is the exception. In no part of the world has the anthropological method of following up certain physical features, such as head-form, hair- and eye-colour, and stature, been used to disentangle the confusion of race-mixture with such

success as in Great Britain and France. The ancestors of the white New-Zealanders were the result of the blending in Britain of a number of ethnic waves, commencing with the long-headed cave-dwellers, whose implements have been found in the river-drift of the late glacial epoch, and ending with the last of the Teutonic series in the recent Norman Conquest. The ancestry of the brown New-Zealanders is still exciting inquiry, but we have been assured that Caucasian and Mongoloid blood entered into it in far-off Asia, and that Negroid and Melanesian elements contributed very slightly during the colonization of the Pacific. Another intermixture should not matter much to either side, since each was long ago deprived of any pretensions to purity of race.

We have not sufficient data to show completely what has taken place with regard to assimilation, but we respectfully submit a few facts for consideration, with the hope that they may be amplified later.

Density of the Maori Population.

By its own natural increase the larger European population (1,218,913, as against 52,751 Maori in 1921) is every year rendering the proportion of the Maori population less and less in the total population of the country. The following table shows that the number of Europeans to one Maori has been steadily increasing in spite of the fact that the Maori population has also been increasing :—

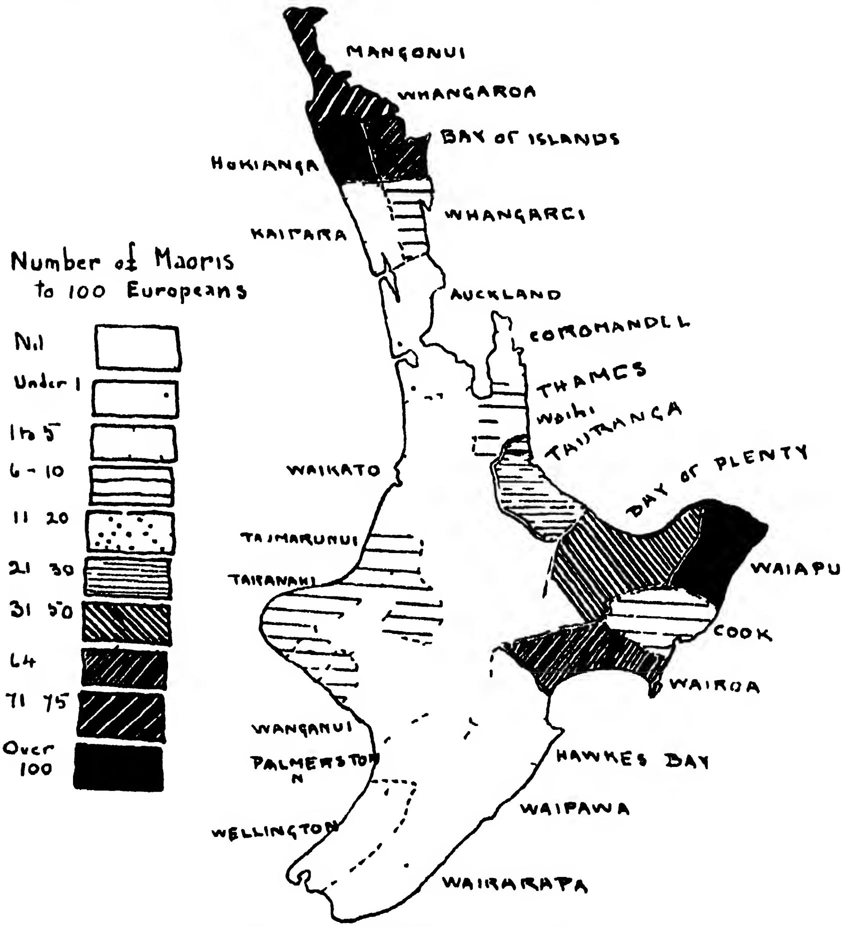
Table 4.—Ratio of Maori to European.

Year.	Number of Europeans to One Maori.
1891	14·9
1896	17·6
1901	17·9
1906	18·6
1911	20·2
1916	22·0
1921	23·6

The proportion of 23·6 Europeans to 1 Maori, or 4·2 Maoris for every 100 Europeans, is the ratio for the total population of both Islands.

The density of the Maori population in particular districts, however, varies considerably. This is clearly shown in the accompanying map. The population of Maoris and Europeans was taken for each hospital district, and the number of Maoris to 100 Europeans shown for each area. The boundaries may not be quite accurate in every particular, but they serve to convey a general idea. The outstanding feature is that there are two areas of dense population, one in the north and one in the east. In the black area of Hokianga, on the west side of the northern area, there are more Maoris than Europeans. To the north and north-east of it lie Mangonui and Whangaroa, with 71 and 74 respectively to the 100 Europeans. To the east lies the Bay of Islands with 64. Though these parts have probably always carried a large Maori population owing to the climate suiting the cultivation of the *kumara*, its present high ratio was further assisted by lesser European settlement. Though containing the oldest European settlements, the area contained so much poor gum-lands unsuitable for closer settlement that European settlers went elsewhere. The Maoris naturally hold the fertile valleys; and except for timber, gum, and trading there was not so much inducement for white occupation. With the opening-up of some of the land, and better travelling facilities,

the European population is increasing, and in the future we may see the shading of this area becoming lighter This density of population has in the past been protected by the isolation the area enjoyed on account of bad roads and comparatively poor country Passing south, we encounter larger towns at Whangarei and Dargaville, with larger white populations, thus further reducing the Maori density to 8 and 12·4 respectively In the Auckland district, in spite of a fairly large Maori population of 1,733, the huge white population reduces the density to less than 1 Owing to



Map of North Island, showing density of Maoris to Europeans, in hospital districts.

prosperous European settlements, the Waikato district, though containing 9,234 Maoris, has its density reduced to 11·9 when spread over its very large area

Turning to the other dense area, in the east, we find that it also has enjoyed isolation in the past Owing to bad roads, land-buyers of the early days sought holdings in more accessible places During those days of isolation the Ngati-Porou Tribe, of Waiapu, learned sheep-farming, and are working their lands themselves Knowing how to utilize their lands, they now refuse to provide the opportunity for excessive European

penetration. Their material prosperity is no doubt having its effect in increasing the population, which for Waiapu is 3,643. East of Waiapu we have the Bay of Plenty, with a fairly dense population owing to conditions being congenial to the Maori, and lack of roads retarding European settlement. Tauranga, farther east, owing to old European settlement, shades off to 27. Below Waiapu we have the comparatively large town of Gisborne reducing the density of the Cook County to 9·7, but farther on Wairoa rises to 64. Wairoa has in the past suffered a certain amount of isolation from bad roads and an uncertain port, whilst the Maori in the district have always been strong. From now on we reach country easily accessible and early acquirable, and so we pass through Hawke's Bay, Waipawa, and Wairarapa, with densities of 3·6, 2·7, and 2·4 respectively. On the west coast from Taranaki to Wellington the same conditions hold, owing to early settlement, early acquisition of Maori land, roads and railways, large towns, and the continuous decrease in the density of the Maori population of the area. If smaller parts of the areas were taken, such as the Wanganui River and Lake Taupo, a slightly different arrangement of shading would be shown in those particular parts.

For the South Island, Picton and Wairau, with 6 and 1·6 respectively, are the only districts with a density not below 1. For the whole of the South Island there are 4 Maoris to 1,000 Europeans. In two Hospital Board districts there are 4 to 10,000 whites, and in three districts there are none at all.

When the density falls very low, the opportunities for assimilation by intermarriage are increased.

MISCEGENATION.

Intermixture between the two races has been going on from the earliest days of colonization. Newman held that half-castes were a feeble race, tending rapidly to extinction, and with no improved fertility. He produced no data to support his statement. I doubt its applicability at the present time, but hope to acquire further data on the subject. In the United States Boas found that in half-breed women the fertility was considerably larger than among full-blooded women. At the present time there is, in the accredited Maori population, a larger percentage with mixed blood than we are apt to think. In the census returns half-castes living as Maoris are counted with the Maori population, and those living as Europeans are correspondingly counted with the European. It would be interesting to know what are the exact boundaries of the two modes of living. In lieu of the 1921 census, if we take the 1916 census and add the European half-castes to it and then work out the percentage of the total half-castes to the full Maori population, we get 6,750 half-castes, or 12·7 per cent. Thus we know definitely that 12·7 per cent. of the 1916 population had European blood in their veins. But this is not the full measure of intermixture, for the children of half-castes with Maori and other combinations are counted as Maori in the census. It would be interesting to know what percentage of the 52,751 in the last census had white blood. Of 814 men of the Maori Battalion examined by me in 1919, 48 per cent. had white blood. Of 4,039 pupils from 94 Native schools the following results were obtained:—

Race.	Number.	Percentage.
Full Maori	2,016	49·9
Maori with white blood	2,023	50·1
	4,039	100·0

These results would indicate that a considerable amount of miscegenation exists. With the increasing dilution of the Maori in so many districts, and improved material welfare and education making both sexes more attractive, miscegenation is likely to increase. Every person of mixed blood marrying a full-blooded Maori adds further to the process of gradual assimilation or absorption. The full Maoris are constantly having their ranks depleted by marriages, not only with full Europeans but with Maoris of mixed blood. The question is whether the full Maoris are reproducing enough to make up for the wastage from their ranks by death and marriage. To keep up their numbers they must, of course, marry full Maoris themselves. Every full Maori who marries any one not of full blood like himself has deliberately stepped outside the narrowing confines of the full-bloods, and the more children he begets the more he is assisting in changing the full Maori into another type.

An idea prevails that the full Maori is really decreasing in this manner, and it is the mixed part of the Maori population that is causing the increase in the census returns. A very significant fact was brought to light by the returns kindly sent me by the Native-school teachers. In the proportion of sexes already dealt with the return for over 4,000 children of full and mixed blood was 921 females per 1,000 males. Returns for 1,159 children of the same series enumerated the sexes in each class from full blood to the various fractions of mixed blood. From them I give the following:—

Race.	Males.	Females.	Number of Females per 1,000 Males.
Full Maori	318	238	748
Mixed blood	313	290	926

The numbers are too small, but the hint is so important that I give them. If in the improved condition of the total Maori population the improvement augured by the increase in the proportion of males applies only to the mixed-blood element, whilst with the full Maori it is falling, as hinted at by the figures 748 per 1,000, then the full Maori will disappear more quickly than we imagined. However, there is need of research work here. The only scientific method to apply is to subject as many settlements as possible to investigation by the genealogical method. Every family should be traced back genealogically until full blood is arrived at on both sides. Thus the amount of miscegenation could be arrived at, and light thrown on various other important matters.

In conclusion, I have to thank the Native-school teachers for sending me returns from their schools showing the proportion of sexes and the amount of mixed blood amongst their pupils. Available data from the census returns has been used to show that the rapid rate of decrease that occurred in the early half of the nineteenth century has ceased, and that the pendulum has begun to swing in the other direction.

The large pre-European population will never be regained by the full-blooded race, but the steady increase of the last twenty years shows there is something in the old tribal proverb, "We will never be lost, for we spring from the Sacred Seed which was sown from Rangiatea."

Miscegenation has stepped in, as it has all down the ages, and will render the assimilation of culture and physical features the stepping-stone to the evolution of a future type of New-Zealander in which we hope the best features of the Maori race will be perpetuated for ever.

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The Food Values of New Zealand Fish: Parts 3 and 4.

By J. MALCOLM, M.D., and T. B. HAMILTON, M.A., B.Sc.

[*Read before the Otago Institute, 12th December, 1922; received by Editor, 31st December, 1922; issued separately, 8th July, 1924.*]

PART 3: SOME CALORIMETRIC ESTIMATIONS.

THIS paper continues the series begun by Mrs. D. E. Johnson (*Trans. N.Z. Inst.*, vol. 52, 1920, pp. 20–26, and vol. 53, 1921, pp. 472–83), and many of the estimations were made on dried-fish powders that had been prepared and analysed by her.

METHODS.

The form of calorimeter employed was the Berthelot-Mahler. The combustion was done in compressed oxygen (25 atmospheres), and the rise in temperature was taken with a Beckmann thermometer graduated in 1/100° C. and read with a lens to 1/500°. The quantity of water used, including the water-equivalent of the bomb, &c., was 2,500 grammes, and our results with substances of known caloric value indicated an experimental error of less than 1 per cent.

Since it was necessary to extract the "fat" with solvents that are themselves combustible, we considered it advisable to test our methods in this way: in several powders we determined the caloric value of the whole, and then the caloric values of the extracted fat and of the residue separately. By comparison we found that no appreciable change, such as absorption of the solvent by the fat or residue, had occurred during the manipulations.

Example: In a dried-fish powder (groper 5—see Table I) we found by analysis 19·50 per cent. fat (= ether-soluble substance), 6·52 per cent. extractives, and a residue, chiefly protein and salts = 74·0 per cent. The caloric value of the fat was found to be 8·6 calories per gramme, of the extractives 5·3, and of the residue 5·6. On calculating the caloric value of the powder from these data we get the figure 6·159 calories per gramme, while the direct estimation of the caloric value of the powder gave 6·165.

Fat.

The ethereal extract of the dry-fish powder was used, since that is usually reckoned as fat in the analysis of foodstuffs. The following values were obtained:—

Table I.

Fish.	No	Caloric Value of Fat per Gramme	Remarks.
Kingfish (haku; *Seriola lalandii*)	1	8·796 calories.. 8·822 8·805 (average)	Fat extracted from dried-fish powder.
Kingfish ..	2	8·857	Same.
Groper (hapuku; *Oligorus gigas*)	5	8·670 8·678 8·674 (average)	Same.
Groper ..	X	9·059 9·045 9·052 (average)	Fat extracted from alcohol-dried fish, low temperature; old.
Groper ..	Y	9·842	Same, but fresh.

These results indicate that during the drying of the fish (but probably in greater degree during its storage)—exposed to the light and to a certain amount of air some oxidation occurs, sufficient to reduce the caloric value from 9·8 to 8·6. It would be interesting to find out how much depreciation of the fuel-value occurs in the cooking of fish, and how fish-fats compare with other fats in this respect.

Unsaponifiable Matter.

When the ethereal extract of fish is saponified with alcoholic potash, a certain amount of fatty material, soluble in ether, remains unattacked. This consists of cholesterols and other alcohols which replace the glycerol of the ordinary fats. We have reason to believe that little, if any, of this unsaponifiable matter is digested or absorbed in the human alimentary tract, and the caloric value of this part of the fat should therefore be subtracted in order to arrive at the true or utilizable fuel-value of the ethereal extract. In the specimen of groper-fat X in Table I the caloric value of the unsaponifiable material was found to be 10·4 calories. In quantity it amounted to about 10 per cent. of the fat, so that while the total fuel-value of the fat was 9·05 calories the true value was only 8·01.

These two considerations—viz., depreciated value on heating and drying, and the presence of a relatively large amount of unsaponifiable matter—both tend to reduce the standard figure (9·1) for caloric value of fat. When applied to fish-fats our estimations indicate a net value not above 8·0 calories per gramme.

Extractives.

In a weak alcoholic extract of the dried-fish powder we obtained a caloric value of 5·3 per gramme. The figure usually given for caloric

value of meat-extract is 3·15. That the higher value in our case was due to substances soluble in ether, and presumably also dissolved out by the alcohol, is shown by the fact that on extracting with ether the caloric value was 3·52. We have not investigated the matter further, but we think it likely that an extract of fish prepared in the same way as commercial extracts of meat would probably have a higher caloric value.

PROTEIN.

A few estimations of the caloric value of the proteins of fish gave an average figure of 5·43—calculated for the water -and ash-free substance. This corresponds closely to the figure for mammalian protein.

ACKNOWLEDGMENTS.

We again beg to acknowledge the grant of money from the Government, through the New Zealand Institute, which made this research possible; also the hospitality of the University of Otago in granting us working-space, gas, light, water, &c.

SUMMARY.

In calculating the fuel-values of fish fats and oils the ease of oxidation before ingestion and the presence of considerable amounts of unsaponifiable matter should be taken into account. Instead of the standard figure, 9·1 calories per gramme, the observations here recorded would indicate a figure about 8·0 calories.

PART 4: COMPOSITION OF THE PAUA (*HALIOTIS IRIS*).

This paper gives an account of some analyses of the shell-fish paua (in this case *Haliotis iris*), which was used as food by the Maori and is also frequently used by Europeans.

The chemistry of molluscs in general has already attracted some attention, but our knowledge of the biochemical processes occurring in them, and especially in the marine forms, is still very meagre. The *Haliotis* has been shown to contain substances rarely met with in the composition of ordinary foodstuffs, or met with in smaller concentration. These comprise taurine (although there are no bile-salts), chlorophyll, haemocyanin, and, among the inorganic constituents, zinc. At the very outset we were impressed with the need for care in applying standard methods of diet-analysis to such material. One reason for this is that the part of the shell-fish used as food includes the alimentary canal and its contents, the glands, heart, and sexual organs; whereas in vertebrate animals used as food only the muscles and certain organs are eaten. The results are that in shell-fish we have a more heterogeneous mixture of materials, the non-protein nitrogen is high, the substances soluble in ether are by no means all fat, and the percentage of unclassified material ("extractives") is considerable.

Our investigations were chiefly directed to the determination of the relative amounts of protein, carbohydrate, fat, and ash.

The paua were obtained from the shore at Pounawea. They were alive when received in the laboratory, and were kindly identified for us by Professor Benham as *Haliotis iris*.

For the purposes of analysis some were divided into a "visceral" part and a "muscle" part, before being dried in an oven at about 55° C. Others were dried similarly without separation into parts, and some were used fresh for glycogen estimation.

Protein.

The usual method of estimating protein in food is to multiply the nitrogen by the factor 6·25 or 6·37. This method is based on the assumptions that most of the nitrogen is in the form of proteins, and that the proteins contain an average of about 16 per cent. nitrogen. Of these assumptions the first, at any rate, cannot be held without reserve in the case of these shell-fish, as the following figures show:—

In one sample of dried paua, "visceral" part, the total nitrogen was found to be 9·0 per cent.; in another sample of the same powder the nitrogen present in an extract made with repeated quantities of strong alcohol followed by a small amount of watery trichloracetic acid was 2·95 per cent.; while that of the residue was 6·35 per cent. The figure 2·95 is due to substances of non-protein nature. If we were to proceed in the orthodox way to calculate the protein percentage from the total nitrogen we should get 58·1 (9·3 × 6·25), or about 15 per cent. of the fresh material. If, on the other hand, we were to take only the nitrogen that is insoluble when treated as described above we should get 39·7 per cent. protein (6·35 × 6·25), or about 10 per cent. of the fresh "viscera." The true figure lies somewhere between these extremes, for some of the nitrogen of the extract may be due to amino acids split off from protein by autolytic changes in the earlier stages of drying, and such amino acids cannot be regarded as entirely valueless.

The above figures refer to the "viscera." A somewhat similar result is given by the "muscle" part, where the total nitrogen was 12·2 per cent. of the solids, and this consisted of 7·54 per cent. insoluble and 4·70 per cent. soluble in strong alcohol. In each case 30 to 40 per cent. of the total nitrogen was not in true protein form, and in such cases it is therefore incorrect to use the factor 6·25.

Carbohydrate.

Using Pflueger's method of estimation, we obtained the following figures for the glycogen percentage of freshly treated *Haliotis iris*:—

Table II.

Sample.	Part.	Weight in Grammes	Amount used (Grammes)	Percentage of Glycogen.
I ..	Muscle ..	156	100	1·20
	Viscera ..	104	104	0·54
II .	Muscle ..	160	100	2·01
	Viscera ..	135	125	0·50

An attempt was made to obtain a clear watery extract for estimation of glucose, so that we might find the total percentage of carbohydrate present, but in spite of various devices the filtration proved so slow that the material began to decompose and had to be abandoned. The cause of

the slow filtration was undoubtedly the large amount of slimy mucus that was present. Glucose could easily be detected in the crude extract.

The glycogen from paua "muscle" gave the usual qualitative tests, and on hydrolysis yielded glucose—at least, so far as we could judge from the fermentation and phenyl-hydrazine tests—but the glycogen from the "viscera" did not react in a typical way. The result of its hydrolysis did not reduce so readily as glucose solutions do, and in one test it failed to ferment with yeast. Unfortunately the time at our disposal did not allow of further investigation while the material was fresh. The origin of the glycogen found in marine shell-fish is worth investigating; for, unlike the terrestrial plants which contain starch, the seaweeds on which the paua, &c., feed contain chiefly pentosanes, methyl pentoses, and pentoses; and the transformation of these into glycogen does not occur readily, if at all, in the vertebrates.

In carrying out Pflueger's method for glycogen (heating for several hours with 30 per cent. KOH) it was found that the glycogen, when precipitated with alcohol, carried down with it a certain amount of greasy material which retarded the filtration. This was almost certainly some of the unsaponifiable fatty matter which had withstood the action of the alkali.

FAT.

In the usual method of analysing foods, the weight of the ethereal extract is returned as "fat." Although it is well known that ether does not extract all the fat, and that it extracts substances that are not fat, yet the method is convenient and suitable when dealing with vertebrate material. In the paua, and presumably in molluscs generally, the faults of the method are more obvious, as can be seen from the following data: The dried visceral portion of paua 3 was extracted with hot alcohol, and then with ether; the alcohol was driven off and its residue extracted with ether; the combined ethereal extract gave, we may presume, all the ether-soluble material as usually estimated. It had a green colour, due to chlorophyll, and amounted to 7·04 per cent. of the solids. This was saponified, and the fatty acids separated, washed, and ultimately weighed. The fatty acid in the ethereal extract was about 73 per cent., whereas in ordinary fats it is about 90 per cent.

In the case of the muscle portion the amount dissolved out by the alcohol and subsequently extracted with ether was between 80 and 90 per cent. of the total fat, whereas in a fish-powder (groper) treated in the same way only 70 per cent. of the fat was extracted by the alcohol.

These observations indicate that the ethereal extract does not represent the true fat-value.

ASH.

The paua is comparatively rich in inorganic salts. The muscle part gave 6·17 per cent. and the whole paua 7·5 per cent., indicating an ash content in the fresh material of from 1·5 to nearly 2 per cent. A qualitative examination of a small quantity of the ash was kindly made for us in the Chemistry Department by Mr. Penseler, under Professor Inglis's directions. The usual elements were found, but in addition Mr. Penseler noted a strong suspicion of the presence of zinc, although he was unaware that that element has been shown to be fairly common in marine shell-fish.

Unidentified Material.

In Table III we give a summary of the analyses of one paua, so far as our analyses were carried. The results show a deficit which is very large in the case of the visceral part. Some of this is no doubt due to the glucose and to remains of vegetable food in the alimentary tract, but these cannot account for more than a small part of the large deficit. The large percentage of material soluble in alcohol in the following sample also indicates the unusual nature of this food: Paua 4 solids, 23·1 per cent. Of the solids, 8·14 per cent. = fat, 7·5 per cent. = ash, and approximately 28 per cent. was soluble in 96 per cent. alcohol, but insoluble in ether.

Table III

	Visceral Part. Grammes.	Muscle Part. Grammes.
(1.) Fresh weight of edible portion	91·00	104·00
(2.) Water percentage	75·70	74·20
(3.) Solids by difference	24·30	25·80
Percentage composition of the solids—		
(4.) Total nitrogen	9·30	12·24
(5.) Non-protein nitrogen	2·95	4·70
(6.) Nitrogen insoluble in alcohol	6·35	7·54
(7.) Protein [maximal − (4) × 6·25]	58·10	76·30
(8.) Protein [minimal − (6) × 6·25]	39·70	47·00
(9.) Glycogen by calculation from Table II	(2·36)	(5·95)
(10.) Fat (ethereal extract)	7·04	6·57
(11.) Ash	*circa* 7·00	6·17
(12.) Minimal deficit 100 − [(7) + (9) + (10) + (11)]	25·50	3·50
(12.) Maximal deficit 100 − [(8) + (9) + (10) + (11)]	43·90	34·30

Remarks.

The foregoing observations indicate that the paua has a considerable value as a food. An adult specimen weighing, say, 200 grm. is probably as much as one would care to eat at a time. It would yield about 2·5 grm. glycogen, 5 grm. fat, 4 grm. to 5 grm. inorganic matter, and, say, 28 grm. protein. The remainder, about 10 grm. solids, consists mostly of substances of uncertain value as food. What has been said above in regard to the unreliability of the standard methods when applied to this shellfish probably holds good for most other invertebrate foods; and, although at first sight it might appear that the investigation of such material is of little consequence on account of the relatively small amount used as human food, yet the analysis of the lower forms of marine life has an important bearing on the question of the food of fishes. For example, it is known that in some cases, such as the herring, the fats of the minute crustaceans on which the fish lives are deposited under the skin with little or no change in chemical character, and there is no doubt that the simultaneous analysis of the fish-fats and of the fats of the lower forms of life found in the same waters would yield important information as to the feeding-habits of the fish.

In conclusion, we beg to thank the University of Otago for facilities in carrying on this work, and to acknowledge again the financial assistance of the research grant from the New Zealand Institute which made it possible.

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Food-supply and Deterioration of Trout in the Thermal Lakes District, North Island, New Zealand.

By W. J. PHILLIPPS, F.L.S., F.R.G.S.

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INTRODUCTION.

THE following paper comprises a section of the results of an investigation on trout food-supply and trout-deterioration, together with a brief notice of other works on these subjects published in various parts of the world. Food-supply for trout is largely dependent on local conditions, and it is only by a study of all interdependent associations, organic or inorganic, which bear on the question that the economic zoologist will be able to decide on an effective manner of increasing the food-supply of a given locality. Owing to continuous destruction of trout food by the Maori, and the presence of various aquatic birds, the study of this subject may become considerably involved. The birds may prey either on the enemies of the trout or the trout themselves, or may in various ways lessen the available food-supply. Accordingly a general survey of the habits of the birds becomes necessary, and also a consideration of the relative depredations of each species.

I have been able to conduct an investigation over a limited period only, and realize that the results so obtained cannot be regarded as fully conclusive. Generally speaking, large lake trout were found to be feeding on fishes, while stream and many inshore trout were found to prefer insects, crayfish, plants, &c. Microscopical slides of stomach-contents were taken immediately after capture of the trout, for as a rule the digestive fluid acts quickly on unicellular organisms, and renders their outline indistinguishable. Except where otherwise signified, all trout dealt with belonged to the rainbow series, and were over two years of age.

I wish to thank Messrs. W. R. B. Oliver and H. Hamilton for their co-operation in determining certain of the species in the table. Mr. Oliver assisted by identifying a number of the plants, while Mr. Hamilton examined the insects. I have also to acknowledge my indebtedness to Professor H. B. Kirk, Victoria University College, Wellington, for his interest and kindly criticisms. Further, my thanks are due to those gentlemen in the Rotorua district who assisted me in securing trout for examination.

SUMMARY OF ANALYSIS OF TROUT STOMACH-CONTENTS.

Altogether 89 trout-stomachs were examined, the contents of which may be summarized as follows: 56 contained fish or fish-remains; 32 contained insects or insect-larvae; 17 contained molluscs; 11 contained crayfish; 31 contained plants; 44 contained microscopical organisms; 33 had stones, sand, or gravel in stomach or intestine; 8 contained the parasitic worm *Histrichus* sp.

I have estimated the proportions of different foods in the total number of stomachs to be—Fishes, 60 per cent.; insects, 18 per cent.; crayfish, 7 per cent.; molluscs, 2·5 per cent.; plants, 12·5 per cent.

Galaxias.—The average length of 16 *Galaxias* sp. from the stomachs of Rotorua and Rotoiti trout was 56 mm. I believe most to be *Galaxias brevipinnis*, but identification cannot always readily be made on partly digested specimens. In all, 23 trout had eaten 132 *Galaxias*, an average of 5¾ per trout.

Gobiomorphus.—The common bully, *Gobiomorphus gobioides*, was found to be the most common fish-food. In order to ascertain the number of this species in a given portion of Lake Taupo close to the beach, I enclosed an area of 30 square yards without disturbing the fish; and, after an hour's observation, was satisfied that there were over 160 examples of the species in the enclosure, together with a few *Galaxias* sp. In the lakes the bully prefers a rocky or pumice bottom and shallow water. I have taken several hundreds during a few minutes' dredging in Western Bay, Lake Taupo. The total length of the adult is generally 123 mm., but all sizes were found in trout-stomachs, the average size of 16 young being 42 mm. Altogether 32 trout had eaten a total of 216 of these fish, an average of 6¾ per trout.

Salmo sp.—Two of the stomachs examined, one from Lake Rotoiti and one from Lake Tikitapu, contained the remains of a young trout.

Insects.—The insect contents of the stomachs examined were generally small, except in the case of stream or river fish. It was noticeable that out of 28 trout-stomachs examined from Lake Taupo only 5 contained insect food. At this season insect food is probably poorer in the lakes than during most months of the year. Dipterous larvae and cicadas were the most commonly found.

Paranephrops.—The crayfish, or koura (*Paranephrops planifrons*), was not largely represented in the trout-stomachs. During October, 1918, I found large numbers in the stomachs of trout from Lake Rotoiti. In the tabulated list 11 trout had taken 17 *Paranephrops*, an average of 1½ per trout.

Potamopyrgus.—The mollusc *Potamopyrgus* spp., of which there are several varieties, is found in all lakes, often being attached to the pond-weed, *Potamogeton Cheesemanii.* Seventeen trout had eaten 188 *Potamopyrgus*, an average of 11 per trout. Allowing for bones and cartilage, I have ascertained that a small *Galaxias* 50 mm. long equals in weight 36 molluscs without the shell.

Plants.—Out of the total 31 stomachs containing plants, 9 contained *Nitella*, 7 *Cladophora*, 4 *Ulothrix*, and 4 *Myriophyllum elatinoides.* Twenty stomachs were examined from the various lakes during September, October, and November, 1918 and 1919, and of these 15 contained an average of 40 per cent. plants. It will be seen that the proportion of plant food eaten was considerably less during February of this year.

Microscopical Organisms.—In 38 stomachs diatoms were found. Other organisms in varying numbers were *Rotifera*, *Paramoecium*, *Amoeba*, and flagellates such as *Pleurococcus* sp. in an encysted condition.

Histrichus.—The parasitic worm was found only in stomachs of trout from Tarawera and Taupo.

Stones, Gravel, and Pumice.—It seems likely that most sand or gravel in the stomach is taken accidentally with other food. In the case of pumice being taken it is possible that here also it had been accidentally swallowed owing to the buoyancy of the stone.

TABLE OF ANALYSES OF TROUT STOMACH-CONTENTS,* 10TH FEBRUARY TO 5TH MARCH, 1921.

Fishes.	Insects.	Crayfish.	Molluscs.	Plants.	Microscopical Organisms.	Remarks.
			LOCALITY—HAMURANA STREAM.			
..	Cicadas, 6	..	*Potamopyrgus*, 11	*Cladophora*, small quantity; blade of grass; seeds of plant	Diatoms, abundant ..	Intestine: numerous *Potamopyrgus*-remains. A yearling trout.
..	Hymenoptera, 7; *Eristalis tenax*, 1; *Lestes colensonis*, 2; Homoptera, 1	..	..	Young leaves and shoots of plant, probably *Ranunculus* sp.	Encysted flagellates, abundant; diatoms, abundant	Intestine: a few cicada-remains. Weight, 1¼ lb.
..	..	..	..	..	..	Stomach contained only wing and feathers of small bird; intestine empty. Yearling.
			LOCALITY - LAKE ROTORUA.			
Galaxias, 8 ..	Dipterous larvae, 2 ..	..	..	*Nitella*, 2 spp., small quantity with fruit	Diatoms, a few ..	Intestine: fish-remains, sand, and gravel. Weight, 4·8 lb.
..	..	*Paranephrops*, 2 (large)	*Potamopyrgus* 14	*Nostoc*, small quantity..	Diatoms, abundant; encysted flagellates, abundant; encysted amoeba, a few	Stomach and intestine: small stones, sand, and gravel.
..	Dipterous larvae, 8 ..	*Paranephrops*, 2	..	..	..	Intestine empty.
Galaxias, 1 ..	..	..	*Potamopyrgus*, 1	..	..	Intestine: sand and gravel. Weight, 3¾ lb.
Galaxias, 2 ..	..	..	..	*Oscillatoria*, small quantity	Encysted flagellates, a few; diatoms, a few	Intestine: fish-remains. Weight, 2¼ lb.
Galaxias, 14 ..	..	..	..	..	..	Stomach: sand and gravel. Intestine: fish-remains. Weight, 4 lb.
Galaxias, 6 ..	..	..	..	..	..	Intestine: fish-remains (a little). Weight, 2¾ lb.
Galaxias, 20 ..	..	..	*Potamopyrgus*, 3	..	Bacteria, bacillus, small numbers	Stomach and intestine: large quantity of sand and gravel. Weight, 3¼ lb.
..	..	..	..	..	..	Stomach empty. Intestine: fish-remains (*Salmo fario*).
Galaxias, 6 ..	..	..	..	..	Diatoms, a few ..	Intestine: digestive fluid.
Galaxias, 11 ..	Dipterous larvae, 12 ..	..	..	..	..	Intestine: remains of about 12 *Galaxias*. Weight, 4¼ lb.
Galaxias, 7 ..	..	..	*Potamopyrgus*, 16	*Cladophora*, small quantity	..	Stomach and intestine: stones, gravel, and fish-remains.
Galaxias, 3 ..	Dipterous larvae, 5 ..	..	..	..	..	Intestine: fish-remains and fine sand.
Gobiomorphus, 1	Cicada, 1	..	*Potamopyrgus*, 11	..	..	Stomach and intestine: fish-remains, sand, and gravel.

* Except where otherwise indicated, all stomachs were taken from *Salmo irideus* or subspecies thereof.

TABLE OF ANALYSES OF TROUT STOMACH-CONTENTS,* ETC.—*continued*.

Fishes.	Insects.	Crayfish.	Molluscs.	Plants.	Microscopical Organisms.	Remarks
LOCALITY—LAKE ROTORUA—*continued*.						
..	..	..	..	..	..	Stomach empty. Intestine: sand and gravel. Weight, 5¼ lb.
Gobiomorphus, 1	Cicadas, 2	..	..	..	..	Intestine: gravel and pumice. Weight, 6 lb.
..	..	..	*Potamopyrgus*, 47	*Nitella*, a large quantity	Diatoms, abundant ..	Stomach and intestine: sand and gravel. Weight, 3¼ lb.
LOCALITY—FAIRY SPRINGS STREAM.						
..	Caddis case, 1 ..	..	..	Small piece of moss ..	..	Intestine empty.
..	..	..	..	..	Encysted amoeba, a few; diatoms, a few	Stomach contained 16 pumice stones and piece of stick. Intestine: pumice and gravel.
..	..	..	..	*Nitella*, a trace ..	Diatoms, a few ..	Stomach: large pumice stone. Intestine empty.
..	..	*Paranephrops*, 1	..	*Nostoc* (?), a little ..	Encysted flagellates, a few	Intestine: crayfish-remains.
..	..	..	..	*Nitella*, small quantity ..	Diatoms, abundant ..	Intestine empty.
LOCALITY—LAKE ROTOITI.						
Galaxias, 6 ..	..	..	..	..	Diatoms, a few ..	Intestine: fish-remains, sand, and gravel.
Galaxias, 4; *Gobiomorphus*, 1	..	*Paranephrops*, 4	..	..	Rotifera, a few ..	Intestine: remains of crayfish. Weight, 7½ lb.
..	Dipterous larvae, 26; *Odontria* sp., 2	..	*Potamopyrgus*, 3	..	Diatoms, abundant ..	Stomach and intestine: sand and gravel.
Galaxias, 9 ..	..	..	*Potamopyrgus*, 1	..	Diatoms, a few ..	Intestine empty.
Galaxias, 4 ..	..	..	..	..	..	Intestine empty.
..	..	..	..	..	..	Stomach empty. Intestine: remains of 4 *Galaxias*. Weight, 5 lb.
Salmo sp. 1 (young)	Cicada, 1	..	*Potamopyrgus*, 5	..	..	Intestine: remains of numbers of small *Galaxias*.
Galaxias, 5 ..	Millipede (?), 1 ..	*Paranephrops*, 1	..	..	..	Intestine: vertebrae of 6 *Galaxias*.
LOCALITY—STREAM, LAKE OKAREKA.						
..	..	*Paranephrops*, 1	..	..	..	Intestine: straw, grass, piece of charred wood. Weight, 4 lb.
..	Cicadas, 5	..	..	..	.	Stomach and intestine: stones and gravel.

			LOCALITY—LAKE OKATAINA.			
..	*Melampsalta cingulata*, 2	..	..	..	♀.	Intestine: small fish-remains. Weight, 5¼ lb.
Galaxias, 1 ..	*Melampsalta cingulata*, 6	..	..	..	Diatoms, a few ..	Intestine: remains of fish and cicadas.
Galaxias, 11 ..	*Melampsalta cingulata*, 2	..	..	..	..	Intestine: remains of fish and cicadas.
..	..	..	..	..	..	Stomach empty. Intestine: fish-remains.
..	..	..	..	..	..	Stomach and intestine empty.
			LOCALITY—LAKE TIKITAPU.			
..	..	*Paranephrops*, 1 (large)	..	*Myriophyllum elatinoides*, a small quantity	Diatoms, abundant ..	Intestine: crayfish and fish remains.
Gobiomorphus, 1	..	..	..	..	..	Intestine: sand and gravel.
..	*Somatochlora*, 4; Hymenoptera (bee), 1; Diptera, 1	..	..	..	Diatoms, a few ..	Intestine: remains of Diptera. Age, 2 years.
..	Larva of *Oxyethira*, 25; imago of *Procordulia smithii*, 1; larva of *Procordulia smithi*, 1; Ichneumon fly, 1; *Melampsalta cingulata*, 4; *Pyronata festiva*, 1	*Paranephrops*, 1	..	*Cladophora*, a quantity..	Diatoms, abundant; encysted flagellates, common	Intestine: 2 feathers and remains of *M. cingulata*. Age, 2 years.
Salmo sp., 1 (young)	..	*Paranephrops*, 1 (large)	..	..	Diatoms, abundant; Rotifera, a few	Intestine: dead leaves, sand, and gravel.
..	Larva of *Sympetrum bipunctatum*, 9; caddis cases, 3	*Paranephrops*, 1 (large)	..	*Nitella*, a little; plant-seeds, common	Diatoms abundant ..	Intestine: caddis cases and cray-fish-remains. Age, 2 years.
			LOCALITY—LAKE ROTOKAKAHI.			
Gobiomorphus, 28	..	..	*Potamopyrgus*, 5	*Nitella*, 2 spp., with fruit, a quantity	Diatoms, abundant ..	Intestine: large quantities of *Nitella* cells empty.
			LOCALITY—PUAENGA STREAM (*Salvelinus fontinalis*).			
	Diptera (*Tipula* sp.), 4..	..	..	*Nitella*, small quantity; *Nostoc*, small quantity; plant-seeds, numerous	Diatoms, numerous ..	Intestine: small quantity sand and gravel. Yearling trout.
..	Dipterous larvae, 4; *Cicindela tuberculata*, 1; weta, 1; traces of another beetle	..	..	..	Diatoms, numerous; encysted flagellates, common	Intestine: weta-remains, sand, and gravel. Yearling trout.
..	Grasshopper, 3 ..	..	..	*Nitella*, common ..	Diatoms, abundant ..	Intestine empty. Yearling trout.
..	Dipterous larvae, 5; Diptera (*Tipula* sp.), 3; grasshopper, 1	..	..	Plant-seeds, common ..	*Paramoecium*, a few; diatoms, common; encysted flagellates, a few	Stomach; also piece of stick, sand, and gravel. Intestine: sand and gravel. Yearling trout.
..	Dipterous larvae, 3 ..	..	..	*Nitella*, common ..	Diatoms, numerous; encysted flagellates, numerous	Intestine: grasshopper-remains. Yearling trout.

* Except where otherwise indicated, all stomachs were taken from *Salmo irideus* or subspecies thereof.

TABLE OF ANALYSES OF TROUT STOMACH-CONTENTS,* ETC.—*continued.*

Fishes.	Insects.	Crayfish.	Molluscs.	Plants.	Microscopical Organisms.	Remarks.
			LOCALITY—LAKE TARAWERA.			
Gobiomorphus, 3	..	..	..	..	..	Intestine: fish-remains; a little sand and gravel.
Gobiomorphus, 2	*Odontria* sp., 1 ..	..	*Potamopyrgus*, 5	..	..	Stomach and intestine: sand and gravel.
Gobiomorphus, 4	..	..	*Potamopyrgus*, 5	Grass-like plant, small quantity	Diatoms, a few ..	Stomach also contained Nematode parasitic worm, *Histrichus* sp. Intestine empty.
Gobiomorphus, 26	..	..	..	..	..	Intestine: *Gobiomorphus*-remains. Weight, 4½ lb.
Gobiomorphus, 12	Cicada, 1	..	..	..	..	Intestine empty.
..	..	..	..	..	..	Stomach: only *Histrichus* sp. Intestine empty.
..	..	*Paranephrops*, 2	*Potamopyrgus*, 34	..	..	Intestine: numerous *Potamopyrgus* shells and fish-remains.
..	..	..	..	..	..	Stomach: 4 *Histrichus* sp.
			LOCALITY—WAIKATO RIVER (ABOVE HUKA FALLS).			
..	*Hydropsyche* larvae, 114	..	*Potamopyrgus*, 16	*Cladophora*, large quantity; *Mougeotia*, small quantity	Diatoms, abundant; encysted flagellates, numerous	Stomach and intestine: sand and gravel. Weight, 8 lb.
			LOCALITY—LAKE TAUPO.			
Galaxias, 2 ..	..	..	..	..	..	Stomach: 4 *Histrichus* sp. Intestine empty.
Galaxias, 3 ..	Spider, 1	..	..	..	..	Stomach and intestine: numerous eggs of spider.
Galaxias, 2 ..	..	..	..	..	..	Intestine: fish-remains.
Galaxias, 4 ..	..	..	..	*Myriophyllum elatinoides*, small quantity	Diatoms, a few ..	Stomach and intestine: small quantity of sand and gravel.
Galaxias, 2 ..	..	..	..	..	..	Stomach: 2 *Histrichus* sp. Intestine: sand.
Galaxias, 1; *Gobiomorphus*, 4	..	..	*Potamopyrgus*, 6	*Potamogeton Cheesemanii*, small quantity	Diatoms, abundant ..	Stomach and intestine: small quantity of sand and gravel. Intestine: fish-remains.
Gobiomorphus, 10	Several dipterous insect remains	..	..	..	..	Stomach: 6 *Histrichus* sp.
Gobiomorphus, 1 (large)	..	..	..	*Ulothrix*, large quantity	Diatoms, abundant ..	Intestine: large quantities of filamentous algae.
Gobiomorphus, 13	..	..	..	..	..	Intestine: remains of *Gobiomorphus*.

Gobiomorphus, 4 (large)	Dipterous insect, 1 ..	..	..	..	..	Intestine: remains of dipterous insects.
Part remains of small fish	..	..	..	*Myriophyllum elatinoides*, large quantity; *Cladophora*, a quantity; moss, small quantity	Diatoms, abundant ..	Intestine: fish-remains.
Gobiomorphus, 8	..	..	..	..	..	Stomach: also 4 *Histrichus* sp. Intestine empty.
Gobiomorphus, 1	..	..	..	..	..	Stomach: also 1 *Histrichus* sp.
Gobiomorphus, 1 (large)	..	..	..	*Myriophyllum elatinoides*, a quantity; *Ulothrix*, small quantity; *Cladophora*, small quantity	Diatoms, abundant ..	Intestine: *Ulothrix* and fish-remains.
Gobiomorphus, 1	Ichneumon fly, 1 ..	..	..	..	Diatoms, numerous; Rotifera, a few	Stomach and intestine: dead leaves, sand, and gravel.
Gobiomorphus, 5	..	..	..	..	..	Intestine: fish-remains.
Gobiomorphus, 18	..	..	..	..	Diatoms, common ..	Stomach and intestine: a little fine sand.
Gobiomorphus, 7	..	..	..	..	..	Intestine: fish-remains, sand, and gravel.
Gobiomorphus, 10	..	..	..	*Oscillatoria*, a quantity ..	Diatoms, abundant ..	Intestine: fish-remains, and a little sand and gravel.
Gobiomorphus, 7	..	..	..	..	..	Intestine: fish-remains. Weight, 7 lb.
Gobiomorphus, 4	..	..	..	..	Diatoms, abundant ..	Intestine: not examined. Weight, 5 lb.
Gobiomorphus, 19	..	..	..	*Oscillatoria*, a little; piece of grass-like weed	Diatoms, abundant ..	Intestine: fish-remains, filamentous algae, and sand.
Gobiomorphus, 3 (large)	..	..	..	..	Diatoms, a few ..	Stomach and intestine: pieces of stick, fish-remains, and a little sand.
Gobiomorphus, 2	..	..	..	*Ulothrix*, small quantity; *Nostoc*, a little	Diatoms, abundant ..	Intestine: fish-remains.
Gobiomorphus, 6	..	..	..	..	..	Intestine: fish-remains, a trace.
Gobiomorphus, 3	*Eristalis tenax*, 1; dipterous larvae, 5	..	..	..	..	Intestine empty.
Gobiomorphus, 5	..	..	..	*Ulothrix*, small quantity	Diatoms, abundant ..	Intestine: fish-remains.
Gobiomorphus, 5	..	..	..	*Cladophora*, large quantity; portions of dicotyledonous leaves; fragments of moss	Diatoms, abundant ..	Intestine: a fragment of moss.

* Except where otherwise indicated, all stomachs were taken from *Salmo irideus* or subspecies thereof.

Trout Food-supply.

Stomachs of the koura (*Paranephrops planifrons*), the tadpole of the Australian frog (*Hyla aurea*), the toitoi (*Gibiomorphus gobioides*), the gudgeon (*Galaxias brevipinnis*), and the koaro (*Galaxias huttoni*) were examined microscopically, and each found to contain enormous numbers of Diatoms, Algae, and Protozoa. Insect-remains were rarely found.

In the years 1918 and 1919 I had the opportunity of examining the stomachs of a number of trout taken in the streams after the close of the spawning season. The stomachs of many were found to be quite empty; some contained stones, and some the eggs of others which had just spawned. Practically all the larger and healthier fish return to the bed of the lake immediately after spawning. Accordingly, stomach-contents of trout taken in streams in the latter part of September and during October and November cannot be regarded as typical. These fish are for the most part females which, owing to weakness or disease, have been unable to deposit their ova at an earlier date. An attempt was made to fertilize ova of such fish artificially, the result being that over 90 per cent. proved sterile.

The tabulated results of analysis of stomach-contents cannot be regarded as forming a true estimate of the general food of thermal trout throughout the year, but will give some idea of the relation and proportion of foods eaten during February. For comparative purposes I submit the results of analysis of trout food-supply by various authors.

Kendall and Goldsborough (1908, p. 47) have found the rainbow trout in the Connecticut lakes to subsist largely on worms and insect-larvae. Note is also made of the great harm done through this predatory species eating the eggs of salmon.

Pearse (1918, p. 274) gives the food-example of *S. irideus* as follows: Insects and insect larvae and pupae, 43 per cent.; amphipods, 42 per cent.; millipeds, 10 per cent.; snails, 5 per cent. Eighteen specimens of *Salvelinus fontinalis* were examined, the average results being Insects and insect larvae and pupae, 57·9 per cent.; millipeds, 0·4 per cent.; mites, 0·4 per cent.; amphipods, 35·5 per cent.; aquatic isopods, 0·5 per cent.; terrestrial isopods, 0·8 per cent.; snails, 1·4 per cent.; plant-seeds, 0·1 per cent.

Hudson (1904, p. 93) has given an excellent series of notes determining the species of insects and insect-larvae forming the staple food-supply of trout in New Zealand rivers. His results show the large extent to which insect food is utilized, but these results cannot be fully recognized as comparable with the existing conditions in the environment of trout in the land-locked lakes of the thermal district. The trout were examined by Hudson during the years 1899–1902, and all were from coastal rivers and streams. The average trout of the Rotorua and Taupo districts is a lake fish associated with shoals of smaller indigenous fishes which persist in much larger numbers than in any New Zealand river which I have examined.

Needham (1902, p. 205) has given a table of the stomach-contents of 25 brook-trout in New York State. The results show an almost complete absence of food other than insects. On p. 206 he states: "I am inclined

to regard only the three first named in the table (*Chironomus, Corethra,* and *Trichopter* larvae and pupae) as of any considerable importance to the trout. To my mind the chief value of this table is that it clearly indicates one species of economic importance to trout-culture—the Chironomid, of whose larvae and pupae an average of 116 specimens had been eaten by the trout. The largest number eaten by a single trout was 351, while three trout had eaten none at all." Needham carried out an interesting experiment by feeding a dragon-fly nymph, *Libellula pulchella,* on *Corethra.* On p. 210 he states: "Placed in the nymph's mouth they were eaten with avidity; but placed thickly in the water with it, and swimming around within easy reach, none were captured, or even reached after, by the nymph. It was probably unable to see them, for it quickly seized water-boatman (*Corisa*) when substituted for the *Corethra* larvae." If aquatic insects are to be introduced into New Zealand as trout-food, it would be well first to have as exact a knowledge as possible of how far the aquatic forms will prey on indigenous species, and also whether the adults acclimatize successfully when mature.

In regard to the suitability of insect food as opposed to fish food for trout, Atkins (1910, pp. 841–51) has shown the potency of the larvae of flies in promoting growth. Experiments carried out by him showed that the fry of salmon fed with insect-larvae exceeded in growth by 27 per cent. those fed on chopped meat. Whether adult trout fed on insect-larvae would thrive to a greater extent than those fed on small fishes remains yet to be proved. The enormous number of insect-larvae which would be required to equal, say, six small fishes 4 in. long may easily make the task of increasing the supply of insects over the large areas of New Zealand lakes much more difficult than the increase in the numbers of small fishes and other forms suitable as food. The small fishes (*Galaxias* spp.) have invariably a large amount of fatty tissue, and in every stomach in which I found one or more of these fish oil-globules were numerous.

Embody (1918, pp. 26–33) has given a record of a number of experiments performed at the experimental hatching-station, Cornell University, the aim being to ascertain a substitute for the fresh-meat food used to feed trout for commercial purposes. An interesting note in regard to the mortality during experimentation is as follows: "In general fingerlings were more susceptible than yearlings and older trout, and rainbow trout were less resistant than brook and brown trout. In nearly all cases this high mortality could be checked in the course of two weeks by changing to a diet of some fresh meat."

Kendall (1918, p. 534) states that the general food-supply upon which the adult fish depends may be divided into two classes—fishes and insects. Further, he adds that in all waters there is a seasonal supply of insect-larvae which varies with the season and locality; but where food in the form of fishes is available the insect food appears to be more or less neglected, particularly by the larger fish.

This statement is interesting when Salmonidae are considered in the light of evolution. It is now recognized that the family as it exists to-day is derived from an ancestral form which existed about the Cretaceous period, and whose natural habitat was the ocean. It will be seen that many of the same types of food may have been utilized by the ancestral form, with the exception of insects. Accordingly insects and insect-larvae have gradually entered into the category of food-supply as Salmonidae have taken to rivers and streams.

Deterioration.

Regarding the growth of trout in the mountain-lakes of eastern Norway in comparison with the degenerate condition of trout on the western side, Dahl (1919, p. 28) notes as follows :—

	West.	East
Food ..	Mostly insects and small organisms	Mostly large animals, fresh-water shrimps, snails, and *Lepidurus*.
Lakes ..	Often deep, and therefore little productive	Often shallow, and therefore more productive.
Spawners .	Small and young, therefore vigorous reproduction	Larger and older, therefore slower reproduction.
Ova ..	Small, with small growth-capacity	Large, with better growth-capacity.

Dahl's researches are of great interest and importance ; but much further investigation seems to be required before these reasons and results may be accepted in their entirety.

Armistead (1920, p. 58) states as follows : " A stock of mountain-trout subjected to a favourable environment may grow and improve for some years. After a time a recoil takes place and the improvement is replaced by a deterioration, apart, as far as I can tell, from the question of food. It is as though the vitality accumulated originally through generations of hardship was exhausted in the process of growth."

Dahl (1919, p. 33) states that " growth depends on the qualities of the mother fish and the size of the ovum (*i.e.*, the size of the yolk-sac of the ovum)." Thus it would seem that, apart from the amount of food-supply available at the stage when feeding commences, the whole future history of the trout depends (1) on the amount of nutriment available for the embryo in the yolk-sac, (2) on what may be termed the inherent constitutional vigour imparted by the parents to their progeny.

There can be no doubt that decreasing food-supply has a direct bearing on the question in the thermal lakes, but I am of the opinion that this is not the solution of the whole problem.

In regard to Dahl's tabulated observations, it would be interesting to ascertain whether outside fry or young trout were introduced into any of the lakes to augment the parent stock ; also whether the trout of the eastern lakes of Norway had greater natural facilities for sexual intermixing than was afforded the trout on the western side. Further, it may be that certain inorganic constituents of the separate waters have been responsible for the predominance of two different types of plankton and benthos.* In the thermal-lakes district I have examined the yolk-sac of the ovum of fishes of different sizes and ages, and have found that in large trout, six to eight years, the yolk-sac is relatively larger than in younger and older trout. The rainbow trout of these lakes reach their maximum weight and condition at about six years. In my opinion it is these large trout (which at the age of six years weigh anything up to 9 lb.) that more than others will be likely to produce a strong and healthy progeny, and thus aid in maintaining the basic standard of the race.

Progeny derived from the same parents may not impress upon their progeny a strong constitutional vigour. Milne (1917, p. 37) writes : " It has been noticed that if eggs are collected annually to the full capacity of a minor tributary in a large watershed, and some of the progeny are

* Phillipps and Grigg (1922) have given considerable data on the relations of organic and inorganic geochemistry to fish life.

planted in the parent stream, the run falls off and may eventually disappear." These remarks refer to the salmon on the Pacific coast of North America. In the state of nature many of the eggs of the adult fish do not arrive at maturity, and the mortality among young fish is generally high; but in the artificial condition of the hatchery the loss is small. The fact that among the progeny liberated as described by Milne as many as several thousand may have been derived from the same parents significantly points to an inbred condition as being the most probable explanation of the run falling off.

At the present time (1923) the phenomenal increase in weight and size of thermal-lake trout is everywhere recognized. It is quite possible from facts to hand in regard to present condition of trout, which in certain lakes average 9 lb. in weight, that these fish have recovered from what may be regarded as a degeneration cycle. Land-locked Salmonidae throughout the world have been known to deteriorate at intervals of several years. Many regard decreasing food-supply as the key to this problem; but this is certainly not the case in the thermal region, where the relative abundance of plankton has not altered since 1918, while the weights of fish have gradually increased since 1919.

Of all aquatic animals able to exist in temperate zones, Salmonidae are perhaps the most susceptible to change of environment, and respond almost immediately to altered conditions of any kind. Apart from human agencies, the geology of the surrounding country, its flora and fauna, altitude, latitude, and climatic conditions must all be considered when dealing with salmon or trout from a scientific standpoint.

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Second Supplement to the Uredinales of New Zealand.

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[*Read before the Wellington Philosophical Society, 24th October, 1923; received by Editor, 31st December, 1923; issued separately, 30th July, 1924.*]

Since Parts 1 and 2 of "The Uredinales, or Rust-fungi, of New Zealand" were published (*Trans. N.Z. Inst.*, vol. 54, pp. 619 704; *ibid.*, vol. 55, pp. 1 58, 1924) the following additional species and hosts have come to hand:-

1. Uromyces Edwardsiae n. sp.* (Fig. 128.) Leguminosae.

0. Spermogones unknown.

III. Teleutosori on pods which have become converted into distorted, rugulose, inflated, piriform galls, attaining a size of 40 × 18 mm.†: chocolate, pulverulent, covering the entire surface, naked. Teleutospores broadly elliptical, less commonly obovate, 30-40 × 22–26 mmm.; apex rounded or bluntly acuminate, slightly (3-4 mmm.) thickened, base attenuate or rounded; epispore 2–3 mmm. thick. conspicuously longitudinally reticulate, with, in addition, a few coarse warts near the apex. pallid chestnut-brown; pedicel deciduous, hyaline, up to 15 × 6 mmm.; germ-pore apical, conspicuous, frequently crowned with a tinted papilla.

Host: *Edwardsia tetraptera* (J. Miller) Oliver (= *Sophora tetraptera* J. Miller). On pods. Herb. No. 1234. III. Tahakopa, Catlins (Southland), 70 m., *C. M. Smith!* March, 1923. (Type.)

The host is indigenous and widespread; it occurs also in Lord Howe Island, Easter Island, Juan Fernandez, and Chile (Cheeseman, 1906, p. 123).

The fungus attacks the pods shortly after flowering, causing them to become distorted and much inflated. In place of the normal pod, 5-20 cm. long, a short piriform gall is formed in its stead. The surface of the gall is much wrinkled and covered with the masses of chocolate-coloured sori. The epispore of the teleutospore is covered with distinct reticulations, arranged in parallel rows which converge at the poles This character separates this from every other species occurring on the genera *Edwardsia* and *Sophora*.

No less than six species of *Uromyces*, and two of the form-genus *Aecidium*, have been recorded as occurring on these two genera, as under:—

II, III. *Uromyces hyalinus* Peck. America. Leaves and stems.
II, III. *U. shikokianus* Kus. Japan. Leaves.
III. *U. cladrastidis* Kus. Japan. Leaves.
III. *U. truncicola* P. Henn. et Shirai. Japan. Stems
II, III. *U. Sophorae-japonicae* Diet. Japan. Leaves.
II, III. *U. Sophorae-flavescentis* Kus. Japan. Leaves.
I. *Aecidium Sophorae* Kus. Japan. Leaves.
I. *A. kowhai* G. H. Cunn. New Zealand. Stems.

The majority of these species of *Uromyces* possess verruculose teleutospores, but none have the peculiar reticulations so noticeable in our species; the gall-forming habit, and habitat on pods, are also characteristic features.

Particulars as to the Japanese species have been obtained from a recent paper by Ito (1922).

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* Latin diagnoses are placed at the end of the paper.

† In this article the contraction "mmm." is used for micromillimetres.

2. Puccinia heketara n. sp. (Fig. 129.) Compositae.

0. Spermogones unknown.

I. Aecidia hypophyllous and caulicolous; on leaves aggregated into irregular closely-packed groups on distorted spots, visible on the upper surface as discoloured areas; on stems scattered over irregular inflated areas which may attain a length of 25 mm., bright orange. Peridia embedded or slightly erumpent, cupulate, 0·5 mm. diam., margin lacerate, slightly reflexed, standing above the leaf-surface about 0·25 mm. Spores elliptical or obovate, 25 35 × 18–22 mmm.; epispore moderately and finely verrucose, 2 mmm. thick, hyaline; cell-contents orange, vacuolate.

III. Teleutosori hypophyllous, seated on minute spots which may or may not be visible on the upper surface, chocolate-brown, circular or irregular in outline, up to 1 mm. diam., frequently less, erumpent. pulverulent. Teleutospores elliptical, 45-55 × 20 26 mmm.; apex rounded

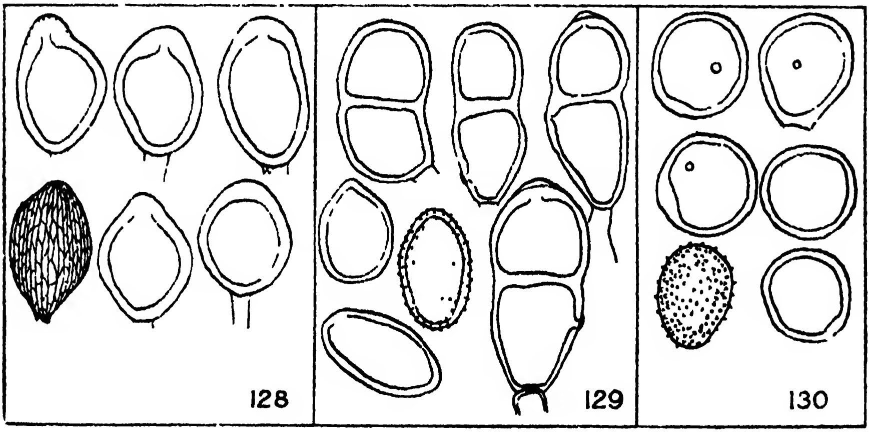

FIG. 128.—*Uromyces Edwardsiae* n. sp.
FIG. 129.—*Puccinia heketara* n. sp.
FIG. 130.—*Uredo Forsterae* n. sp.

or bluntly acuminate, not or slightly (3 mmm.) thickened, base attenuate, lower cell slightly longer and narrower than the upper; constricted at the septum; epispore smooth, 1·5–2 mmm. thick, pallid chestnut-brown, cell-contents vacuolate; pedicel deciduous, hyaline, stout, up to 25 × 8 mmm.; germ-pore of the upper cell apical, basal pore between one-third and two-thirds below septum, both conspicuous and papillate.

X. Mesospores rare, obovate, 28–40 × 16 23 mmm.

Host: *Olearia Cunninghamii* Hook. f. On leaves, petioles, and stems. Herb. No. 1244. I–III. York Bay (Wellington), 100 m., *E. H. Atkinson!* (Type.)

The host is endemic, and abundant throughout the North Island and lowland forests of Marlborough and Nelson (Cheeseman, 1906, p. 286).

This rust closely resembles *Puccinia Atkinsonii* G. H. Cunn. (on *Olearia excorticata* Buch.), but differs in many minor characters, especially in the non-retuse apex, thinner epispore, and smaller size of the teleutospores.

3. **Uredo Forsterae** n. sp. (Fig. 130.) Candolleaceae.

II. Uredosori hypophyllous, on irregular yellow spots, scattered, elliptical, 1–2 mm. long, dark chestnut-brown, bullate, pulverulent, surrounded by the ruptured epidermis. Uredospores globose to obovate, 24–31 × 18–25 mmm.; epispore finely bluntly and moderately echinulate, chestnut-brown, 1·5–2 mmm. thick, with 2–3 obscure equatorial germ-pores.

Host: *Forstera Bidwillii* Hook. f. On leaves. Herb. No. 1272. II. Mount Egmont (Taranaki), 1,000 m., *E. H. Atkinson!* 2 Feb., 1923.

The host is endemic, and distributed through the mountain-ranges of both Islands (Cheeseman, 1906, p. 393).

These three species bring the total of species collected in New Zealand to 124, this number being distributed in the following genera: *Uromyces*, 14; *Uromycladium*, 4; *Puccinia*, 68; *Gymnoconia*, 1; *Phragmidium*, 5; *Hamaspora*, 1; *Coleosporium*, 1; *Melampsora*, 2; *Melampsoridium*, 1; *Pucciniastrum*, 1; *Milesina*, 1; *Aecidium*, 11; *Uredo*, 14.

ADDITIONAL HOSTS.

These hosts have come to hand since the publication of the two previous papers.

GRAMINEAE.

Puccinia graminis Pers. (*Trans. N.Z. Inst.*, vol. 54, p. 644, 1923).

Agropyron scabrum (Lab.) Beauv. On culms. Herb. No. 1273. III. Queenstown (Otago), 500 m., *W. D. Reid!* 5 June, 1923.

Poa aquatica L. On leaves. Herb. No. 740. II, III. Araraki (Hawke's Bay), 35 m., *G. H. C.* 22 Feb., 1922.

The former host is indigenous and widespread, and occurs also in Australia (Cheeseman, 1906, p. 923). The latter host is an introduced species.

CYPERACEAE.

Puccinia Caricis Schroet. (*l.c.*, p. 649).

Carex appressa R. Br. On leaves. Herb. No. 367. III. Bluff (Southland), sea-level, *W. D. Reid!* 26 May, 1922.

The host is endemic, and confined to the South, Stewart, and several of the outlying islands (Cheeseman, 1906, p. 814).

Puccinia Unciniarum Diet. et. Neg. (*l.c.*, p. 650).

Uncinia australis Pers. On leaves. Herb. No. 597. II, III. Pencarrow (Wellington), sea-coast, *E. H. Atkinson!* 21 Jan., 1923.

The host is indigenous, and not uncommon throughout the lowland areas; it is said to occur in the Sandwich Islands (Cheeseman, 1906, p. 802).

POLYGONACEAE.

Puccinia tiritea G. H. Cunn. (*l.c.*, p. 654).

Muehlenbeckia axillaris (Hook. f.) Walp. On leaves. Herb. No. 1274. II, III. Ettrick (Otago), 300 m., *G. H. C.* 24 March, 1923.

The host is indigenous and widespread; it occurs also in Tasmania and Australia (Cheeseman, 1906, p. 593).

ONAGRACEAE.

Puccinia pulverulenta Grev. (*l.c.*, p. 665).

Epilobium junceum Sol. On leaves. Herb. No. 593. II, III. Shore of Lake Taupo (Auckland), 400 m., *E. H. Atkinson!* 9 March, 1922.

Epilobium pictum Petrie. On leaves. Herb. No. 508. II, III. Cass (Canterbury), 800 m., *W. D. Reid! N. R. Foy!* 19 Jan., 1922.

Epilobium pubens A. Rich. Herb. No. 1275. II, III. Wakatipu (Otago), 400 m., *W. D. Reid!* 5 June, 1923.

E. junceum is indigenous and abundant throughout both Islands, and occurs also in Australia; *E. pictum* is endemic and confined to the mountain regions of the South Island; *E. pubens* is indigenous and abundant throughout, and occurs also in Australia (Cheeseman, 1906, pp. 174–76).

COMPOSITAE.

Puccinia fodiens G. H. Cunn. (*l.c.*, p. 682).

Celmisia spectabilis Hook. f. Herb. No. 750. II. Mount Waiopehu (Wellington), 1,700 m., *G. H. C.* 26 Oct., 1919. Sugarloaf, Cass (Canterbury), 1,000 m., *W. D. Reid! N. R. Foy!* 20 Jan., 1922. Waiouru–Tokaanu Road, Taupo, 1,000 m., *E. H. Atkinson!* 13 March, 1922.

Puccinia novae-zelandiae G. H. Cunn. (*l.c.*, p. 686).

Olearia arborescens (Forst. f.) Cockayne and Laing (= *Olearia nitida* Hook. f.). On leaves. Herb. No. 790. I. Mount Egmont (Taranaki), 1,000 m., *E. H. Atkinson!* 4 Feb., 1923.

Olearia avicenniaefolia (Raoul) Hook. f. Herb. No. 600. I, III. Franz Josef Glacier (Westland), 250 m., *W. D. Reid!* 28 June, 1922.

Both hosts are endemic, *O. avicenniaefolia* being confined to the South and Stewart Islands, *O. arborescens* being abundant throughout (Cheeseman, 1906, pp. 285, 291).

CORRECTION.

Miss E. M. Wakefield in a recent letter has pointed out that *Puccinia Hoheriae*, described as new on page 661, *Trans. N.Z. Inst.*, vol. 54, has already been published by her in the *Kew Bulletin*, the species being named from material forwarded to Kew in 1917 by A. H. Cockayne. This species should therefore be cited—

P. Hoheriae Wakef., *Kew. Bull. Misc. Inf.*, p. 312, 1917.
Syn. *P. Hoheriae* G. H. Cunn., *Trans. N.Z. Inst.*, vol. 54, p. 661, 1923.

I am indebted to Miss Wakefield for drawing my attention to this matter.

LATIN DIAGNOSES.

Uromyces Edwardsiae sp. nov. (Fig. 128.)

0. Incognitis.

III. Soris teleutosporiferis in sufflatis, rugosis siliquae sedere; ad 40 × 18 mm., brunneo-nigris, pulverulentibus, nudis. Teleutosporis late ellipticis v. obovatis, 30–40 × 22–26 mmm.; apice rotundato v. acuminato, leniter 3–4 mmm. incrassato, basi attenuato v. rotundato; episporio reticulato, 2–3 mmm. crasso, castaneo; pedicello deciduo, hyalino, ad 15 × 6 mmm.; foramine germinis apicale, conspicuo, saepe papillato.

Hab.: In siliquae *Edwardsiae tetrapterae* (J. Miller) Oliver. Tahakopa, Southland, New Zealand, 70 m. *C. M. Smith.*

Puccinia heketara sp. nov. (Fig. 128.)

0. Incognitis.

I. Aecidiis hypophyllis et caulicolisque, in magnis catervis in maculis detorsis quae desuper cerni possunt solide confertis, ad 25 mm. longis, irregularibus, luteis. Peridiis immersis v. leviter erumpentibus, cupulatis, ad 0·5 mm. diam., marginibus laciniatis, leniter incurvatis. Aecidiosporis ellipticis v. obovatis, 25–35 × 18–22 mmm.; episporio minute verrucoso, 2 mmm. crasso, hyalino.

III. Soris teleutosporiferis hypophyllis, in maculis minutis nigro-brunneis, brunneo-atris, rotundis v. irregularibus, ad 1 mm. diam., erumpentibus, pulverulentis. Teleutosporis ellipticis, ad 45–55 × 20–26 mmm.; apice rotundato v. acuminato, non v. leniter (3 mmm.) crassato, basi attenuato, ad septum constricto; episporio leve, 1·5–2 mmm. crasso, castaneo, contentu vacuolato; pedicello deciduo, hyalino, ad 25×8 mmm.; foramine germinis cellulare superioris apicale, foramine basili ad $\frac{1}{3}$–$\frac{2}{3}$ intra septum, conspicuo papillato.

X. Mesosporis raris, obovatis, ad 29–40 × 16–23 mmm.

Hab.: In foliis vivis *Oleariae Cunninghamii* Hook. f. I–III. York Bay, Wellington, New Zealand, 100 m. *E. H. Atkinson.*

Uredo Forsterae forma sp. nov. (Fig. 130.)

II. Uredosoris hypophyllis, in irregularibus maculis flavis, raris, ellipticis, ad 1–2 mm. longis, castaneis, bullatis, pulverulentis, epidermide rupta cinctis. Uredosporis globosis v. obovatis, ad 24–31 × 18–25 mmm.; episporio subtiliter echinulato, castaneo, 1·5–2 mmm. crasso, cum 2–3 foraminibis germinis in circulo aequinoctialis, indistinctis.

Hab.: In foliis vivis *Forsterae Bidwillii* Hook. f. II. Mount Egmont, Taranaki, New Zealand, 1,000 m. *E. H. Atkinson.*

LIST OF SPECIES AND HOSTS DISCUSSED HEREIN.

Species.

Puccinia Caricis *Schroet.*
Puccinia fodiens *G. H. Cunn.*
Puccinia graminis *Pers.*
Puccinia heketara *G. H. Cunn.*
Puccinia Hoheriae *Wakef.*
Puccinia Hoheriae G. H. Cunn.
Puccinia novae-zelandiae *G. H. Cunn.*
Puccinia pulverulenta *Grev.*
Puccinia tiritea *G. H. Cunn.*
Puccinia Unciniarum *Diet. et Neg.*
Uredo Forsterae *G. H. Cunn.*
Uromyces Edwardsiae *G. H. Cunn.*

Hosts.

Agropyron scabrum (*Lab.*) *Beauv.*
Carex appressa *R. Br.*
Celmisia spectabilis *Hook. f.*
Edwardsia tetraptera (*J. Miller*) *Oliver.*
Epilobium junceum *Sol.*
Epilobium pictum *Petrie.*
Epilobium pubens *A. Rich.*
Forstera Bidwillii *Hook. f.*
Muehlenbeckia axillaris (*Hook. f.*) *Walp.*
Olearia arborescens (*Forst. f.*) *Cockayne and Laing.*
Olearia avicenniaefolia (*Raoul*) *Hook. f.*
Olearia Cunninghamii *Hook. f.*
Olearia nitida Hook. f.
Poa aquatica *L.*
Sophora tetraptera J. Miller.
Uncinia australis *Pers.*

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The Ustilagineae, or "Smuts," of New Zealand.

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Plates 44–47.

THIS group of fungi is characterized by the production of masses of dark-coloured spores in or on the leaves, stems, or inflorescences of Phanerogams. On account of the dark colour and usually powdery nature of the spore-masses, members of this suborder are popularly termed "smuts." Many are of considerable economic importance, for, where preventive methods are not practised, certain species cause a heavy annual loss to those engaged in the culture of cereals and grasses. On this account they have for the past half-century been the subject of considerable investigation by mycologists, with the result that in most cases their structure and life-history are well known.

The spore-mass, or sorus, consists of numerous spores which at maturity may be free and one-celled, or may be aggregated into spore-balls; in certain genera many of the spore-balls are surrounded completely or in part by sterile cells. Various names have been applied to the spores by different workers (*e.g.*, "chlamydospores," "teleutospores," "brand-spores," "pseudospores," "resting-spores"), but in this paper they will be termed simply "spores." The spore, on germination, usually produces a structure bearing lateral or terminal conidia. This body has been variously named (*e.g.*, "promycelium," "germinal tube," "hemibasidium," "probasidium," "basidium"), but in accordance with its significance in classification it should more properly be termed a "basidium." Unfortunately, its behaviour is so varied in different genera and species as to make it impracticable to apply this term (see under *Ustilago*); to avoid confusion the term "probasidium" is used in this paper, for this implies that it is the forerunner of the basidium, an opinion held by many modern taxonomists. In the majority of cases the probasidium gives rise to hyaline continuous spores (variously termed "sporidia," "sporidiola," "promycelial spores," "conidia"), to which in this paper the term "conidia" will be applied. A conidium, on germination, produces a hypha (infection hypha) which penetrates the host-tissues, where under favourable conditions it gives rise to a mycelium, from which eventually the spores develop.

All species undergo this cycle, but, as might be expected, the details vary considerably in different genera, and even in different species in the same genus. These differences, in so far as they concern New Zealand species, are dealt with under the respective species in which they occur.

Members of the Ustilagineae are usually considered to be obligate parasites. Strictly this is nor the case, for Kniep (1921) has successfully grown *Urocystis Anemones* Wint. on culture media, the full cycle being completed thereon. Many species may be grown on media, where they produce abundant mycelium, but this is the first recorded instance in which spore-formation occurred. Then, too, at one stage in the cycle every species is saprophytic, producing probasidia and conidia (when these occur in the cycle) in the soil.

MORPHOLOGY.

Mycelium.

When a conidium germinates it produces a small infection hypha, which, if conditions are favourable, penetrates the tissues of the host. There it branches repeatedly to form a mycelium, the hyphae of which derive their necessary food substances from the host-cells. The hyphae ramify between and send into the host-cells minute botryoidal or irregular haustoria; occasionally the hyphae have been found to penetrate into the cells.

Infection may occur when the host is in the seedling stage (as in *Ustilago Avenae*, *U. levis*, *Tilletia Tritici*), at the time of flowering, through the stigma (*Ustilago Tritici*), or locally through the stem or leaf (*Urocystis Anemones*). Further particulars are given under the respective species.

The mycelium is difficult to detect in the host, partly owing to the minute size of the hyphae, and partly owing to the fact that at the time of spore-formation the hyphae commonly undergo gelatinization; but they may generally be observed in the vicinity of the developing sori. They are usually much septate, narrow, being only 2 or 3 micromillimetres thick, and have comparatively thick hyaline walls. The mycelium often persists in the perennial parts of the host, and in the spring grows into and infects the developing leaf and shoot. The hyphae may stimulate the host-cells to excessive division; consequently, with certain species, large galls are formed in the vicinity of the sorus (*e.g.*, *Ustilago Zeae* Ung.).

Spores.

These develop directly from the mycelium. They are usually produced in the inflorescences, replacing the ovules, but may also be formed within the tissues of the leaves and stems. From the vegetative mycelium, in certain restricted areas, special short hyphae are produced which are cut off by septa from the vegetative mycelium; they then become somewhat rounded, and the outer walls become partly gelatinized. Within these gelatinized walls, in the lumen of the cell, the spore develops, first appearing as an undifferentiated mass of protoplasm, which later becomes surrounded by a two-layered wall. As details of development differ in the different genera, they are more suitably dealt with under each genus. The spore at maturity consists of a two-layered wall—a hyaline, rather delicate endospore, and a well-defined, coloured epispore—enclosing the protoplasm, which is colourless, contains numerous oil-globules, and a single nucleus in which is a large nucleolus. The epispore may be smooth, finely or coarsely verruculose, or reticulate.

Germination.

Spores may germinate as soon as mature, or may require a more or less protracted period of rest. The method of germination differs considerably in different genera, and even in different species in the same genus. These differences are more conveniently discussed under each genus and species. In general, however, there are two methods of germination, and upon them is based the separation of the two families—Ustilaginaceae and Tilletiaceae—of which the suborder is usually constituted. A short probasidium is produced; on it are borne either lateral and terminal conidia (Ustilaginaceae), or else one or many terminal conidia, which, if numerous, are arranged in a whorl (Tilletiaceae). Exceptions occur, such

as when a probasidium is produced which develops directly into an infection hypha, conidia being absent. In such a case the species is placed in one or other family on account of the possession of certain other characters. (See under "Taxonomy.")

In water the conidia produce short infection hyphae, seldom secondary conidia, but in nutrient solution they often give rise to secondary or tertiary conidia by a process of budding.

CYTOLOGY.

The vegetative mycelium (prior to the formation of spores) is invariably binucleate until shortly after gelatinization of the walls of the sporogenous hyphae, when the two nuclei fuse, the mature spore being uninucleate. When the spore germinates the protoplasm passes into the probasidium, but the nucleus usually remains within the spore and there divides, the daughter nucleus passing into the probasidium.

In *Ustilago* this probasidial nucleus and the one within the spore again divide, and all then migrate into the probasidium, where each takes up such a position that when the probasidium becomes septate each cell contains one nucleus. As each conidium is formed, one of the probasidial nuclei divides and the daughter nucleus migrates into the conidium. In those members of this family in which conidia are produced the conidia often conjugate, a short conjugation-tube passing from a conidium to one adjacent, with which it fuses, or both may produce tubes which meet and fuse. Through the tube the nucleus of one conidium passes to the other, where it remains, but does not fuse with its fellow. When this binucleate conidium germinates it produces an infection hypha, the cells of which are binucleate owing to simultaneous division of the two nuclei. This binucleate condition persists until spore-formation.

In *Tilletia* the probasidium is at first non-septate, and the spore nucleus divides until the number of daughter nuclei corresponds with the number of terminal conidia produced, into which they pass. In *Tilletia* conjugation occurs whilst the conidia are still attached to the probasidium. Here a short conjugation-tube is produced; this fuses with a contiguous conidium (or conidial tube), and the nucleus of the one migrates to the other. As in nutrient solution these conidia may produce an aerial mycelium from which secondary conidia arise, it follows that this mycelium, together with the secondary conidia, is binucleate.

In those species of either genus in which no conidia are produced conjugation is effected between neighbouring hyphae derived from the probasidium. Short lateral outgrowths are produced; these fuse, and the nucleus of one migrates into the cell of the other. In this manner the mycelium becomes binucleate. Exceptions occur, however, for Rawitscher (1912) has shown that with *Ustilago Maydis* Cda. (= *U. Zeae* Ung.) the conidia do not conjugate, the mycelium remaining uninucleate throughout its vegetative existence until the period of spore-formation, when during the formation of the sporiferous hyphae the ends of adjacent cells come in contact, their walls break down, and two nuclei come together in the swollen terminal region so produced. These nuclei fuse almost immediately, so that the developing spores are uninucleate as in normal plants.

This matter cannot here be discussed at greater length; further particulars may be obtained from the papers of Dangeard (1894), Harper (1899), Lutman (1911), Rawitscher (1914), Kniep (1921).

REMEDIAL TREATMENT.

Owing to the economic importance of these fungi, mycologists in various parts of the world have carried out considerable work on their control. According to the methods of infection, this remedial treatment may be classed under the two heads—(i) Destruction of seed-borne spores by steeping in some fungicide; (ii) destruction of perennating mycelium in the seed.

(i) Many species are perpetuated by spores carried on the seed; these germinate and infect the host in the seedling stage (*e.g.*, *Ustilago Avenae*, *U. levis*, *U. bromivora*, *U. Jensenii*, *Tilletia levis*, and *T. Tritici*); in fact, the majority of the species of economic importance are included in this group.

The treatment recommended is to steep the seed in some fungicide which destroys the spores without materially affecting the germination of the seed. Of the many solutions tried, formalin and copper-sulphate have been most widely used; unfortunately, both, though effective as fungicides, impair the germinating-vitality of the seed

Successful trials have recently been made with other fungicides, one of the most promising being powdered copper-carbonate, first recommended by Darnell-Smith (1917; 1921). For particulars as to the methods of treatment, and a *résumé* of the effect of these three substances on the germination of wheat, see Neill (1923) who also gives a bibliography of recent experimental work in this connection.

German chemists have since 1914 been experimenting with considerable success with various organic and inorganic compounds in connection with smut-control, excellent results being claimed for certain mercury-chlorine-phenol derivatives sold under the trade names of "Uspulun," "Germisan," &c. Samples of some of these compounds are now available, and will be tried out in this laboratory with a view to ascertaining whether they are applicable under New Zealand conditions.

(ii.) Other species are perpetuated by means of hibernating mycelium in the ovule (*e.g.*, *Ustilago striaeformis*, *U. Tritici*). This mycelium remains quiescent until the seed germinates, when it grows with the growing-point of the host until the formation of the inflorescence, eventually replacing the ovule by a mass of spores. Needless to say, external treatment with a fungicide is useless as a control in this case, since it cannot reach and destroy the internal mycelium.

Jensen (1888; 1889A) demonstrated by numerous experiments that if the seed were soaked for a few hours in cold water, then for a few minutes in hot water (53° C.), infection by *Ustilago Avenae* and "*U. nuda*" was prevented. Freeman and Johnson (1909) found by experimenting with Jensen's modified hot-water treatment that "*Ustilago nuda*" and *U. Tritici* could be entirely held in check. Their methods are summarized below:—

For barley, soak in cold water for five hours; follow by soaking in hot water at a temperature of 52° C. for fifteen minutes. For wheat, soak in cold water for five hours; follow by soaking in hot water at 54° C. for ten minutes. The seed may afterwards be stored for some time without detriment. Germination is but slightly affected if the treatment is carefully carried out.

Osner (1916) has shown that the hot-water treatment is also an efficient controllant of *Ustilago striaeformis*. It could also be used for all the cereal smuts, but the work entailed is such that most growers prefer the simpler chemical steeps.

A third method of combating these diseases is that of the production of resistant strains of the hosts. Unfortunately, little work in this connection has as yet been attempted on an extensive scale. That such strains do exist is readily demonstrable. For example, Mr. S. Hill, of Auckland, has selected a strain of *Bromus unioloides* (a plant that in New Zealand is invariably infected with *Ustilago bromivora*) which, although constantly grown side by side with infected plants, yet remains free from smut. I understand Mr. Hill intends to place seed from this smut-resistant strain on the market.

TAXONOMY.

The earlier systematists of last century had apparently vague ideas as to the position this suborder should occupy, for they usually included it as a subgenus of the genus *Uredo*. This close association with the rusts continued until the appearance of a paper by the brothers Tulasne (1847). In this paper, as a result of germination experiments, they separated the family Tilletiaceae from the Ustilaginaceae. They also discussed the position that they believed the suborder should occupy, comparing and contrasting it with the rusts. In a later work (1854) L. R. Tulasne sketched out the position he believed these two groups should occupy, suggesting their affinities; it is interesting to note that this work has largely been confirmed by modern workers.

Brefeld (1883) placed the suborder in the Hemibasidii, for he considered its members to be intermediate in position between the Basidiomycetes and the Phycomycetes, having arisen from the latter. He considered the probasidia to be of the nature of a basidium, and considered that the presence of this structure showed the group to be more closely related to the Basidiomycetes. He believed those Basidiomycetes with septate basidia to have arisen from the Ustilaginaceae, those with simple basidia to have arisen from the Tilletiaceae, for he believed the former to possess septate, the latter continuous basidia. As will be shown below, species and genera placed by him in the Tilletiaceae also possess septate probasidia.

Moeller (1895) erected for the Ustilagineae the order Protobasidiomycetes; this he divided into six families, all with septate basidia. He considered *Tilletia* to be the progenitor of those families possessing cruciate basidia, and *Ustilago* to have given rise to those with transversely septate basidia.

Patoulliard (1900) has arranged the classification of the Basidiomycetes in such a manner as to show the affinities of each order; his arrangement is such a convenient one that it will in part be followed in this paper in so far as the position of the Ustilagineae is concerned.

He divides the Basidiomycetes into two subclasses, Homobasidiae and Heterobasidiae, the latter being characterized by the septate or simple basidia, spores on germination producing conidia which form a mycelium reproducing the fructification. The Heterobasidiae he divides into four orders—Auriculariales, Tremellales, Tulasnellales, and Calocerales; in the first (characterized by the transversely-septate basidia) are included five suborders, of which the Ustilagineae is one. It is characterized by the probasidia being multiseptate, and the cells pleurosporous.

The suborder is usually divided into the two following families:—

USTILAGINACEAE	..	Probasidium usually with lateral and terminal conidia.
TILLETIACEAE	..	Probasidium usually with terminal conidia.

If the two methods of germination set out above are considered to be of sufficient importance to warrant the maintenance of two families, then, logically, a third family must be erected to contain those species (occurring in both the Ustilaginaceae and Tilletiaceae) the spores of which on germination give rise directly to an infection mycelium, a true probasidium being absent. This has not been done, however, and when these species have been encountered by workers they have been placed in one or other family on account of the possession of certain other characters. For example, it is often claimed– first by Brefeld (1883) –that the probasidia of the Ustilaginaceae are invariably transversely septate, those of the Tilletiaceae being continuous; but careful examination of mature cultures of members of the Tilletiaceae shows that the probasidia in this family also are transversely septate.

A third method of differentation considered to be of value is that of spore-formation, for it is claimed that it is intercalary in the Ustilaginaceae, acrogenous in the Tilletiaceae. This character holds in so far as *Ustilago* and *Tilletia* are concerned, but when the development of the spores of those genera in which spore-balls occur is considered, as in *Sorosporium* and *Urocystis*, it is seen that in essentials the method of development is identical in each.

It is thus obvious to the systematist that the characters upon which the two families have been erected are not sufficiently distinct to warrant their retention; consequently the two should be merged in one, the Ustilaginaceae (the older name). This merging of the two families is by no means a new idea, for it has already been effected by several writers, among whom may be mentioned van Tieghem (1893), and Tubeuf and Smith (1897).

The suborder is poorly represented in New Zealand, for only twenty-three species are here recorded, included in seven genera. This is in marked contrast to the rusts, of which some 124 species have been collected and recorded. It is probable that many additional species will be added to the New Zealand records in the future; as specimens come to hand they will be dealt with in subsequent papers.

The writer believes that the object of any taxonomic paper is to present in such a manner as to enable any one to determine with a reasonable degree of accuracy the species discussed therein; consequently in this paper only species possessing distinct morphological characters are considered, those that have been separated on biologic grounds being relegated to the waste-paper basket of synonymy. For if biologic races are considered as species (necessitating germination experiments, cultural experiments, &c., to prove their identity), then the work entailed in their determination would defeat the object of the paper.

All descriptions are original, and unless otherwise stated are drawn up from material in the herbarium of the writer. All drawings have been made with the aid of a camera lucida, from spores mounted in 50 per cent. lactic-acid solution. Only mature spores have been drawn and measured; these have been obtained by shaking the specimen over a sheet of clean notepaper.

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USTILAGINACEAE.

Endophytic fungi parasitic upon Phanerogams. Mycelium either localized or widely dispersed, of hyaline septate hyphae. Spores arising in compacted masses of sporiferous hyphae, modified from the vegetative mycelium. Sori evident, forming compact or pulverulent spore-masses in definite areas on the host, or more rarely permanently embedded within the host-tissues. Spores coloured, smooth or variously sculptured, occurring singly or aggregated into spore-balls, the latter often partially or wholly enclosed within a membrane of sterile cells. Germination by means of a probasidium on which are usually produced lateral or terminal conidia.

In the family Ustilaginaceae (including the Tilletiaceae) are included twenty-one genera, seven of which have been collected in New Zealand. Among the various mycologists who have worked with the suborder, opinions are divided as to the number of genera that should be retained. For example, Clinton (1906) includes under the Ustilaginaceae (excl. Tilletiaceae) the following eleven genera: (1) *Ustilago*, (2) *Sphacelotheca*, (3) *Melanopsichium*, (4) *Cintractia*, (5) *Schizonella*, (6) *Mykosyrinx*, (7) *Sorosporium*, (8) *Thecaphora*, (9) *Tolysporella*, (10) *Tolyposporium*, and (11) *Testicularia*. Under the Tilletiaceae he includes (1) *Tilletia*, (2) *Neovossia*, (3) *Tuburcinia*, (4) *Urocystis*, (5) *Entyloma*, (6) *Burrillia*, (7) *Doassansia*, and (8) *Tracya*. Of these, Dietel (1900) includes *Cintractia* and *Sphacelotheca* under *Ustilago*, and lists in addition the two genera *Anthracoidea* Bref. and *Poikilosporium* Dietel. *Anthracoidea* is now considered to be a synonym (and in this paper listed as such) of *Cintractia*; the second, according to Clinton, is a synonym of *Thecaphora*. To those listed by Clinton may be added *Melanotaenium* De By. and *Elateromyces* Bubak, the latter of recent origin. Of those other genera that have been proposed from time to time, *Rhamphospora* D. D. Cunn. is placed by Clinton under *Entyloma*; *Doassansiopsis* Setch. is placed by the same author under *Doassansia*; *Cornuella* Setch. is placed by Sydow (1901) under the genus *Tracya*; *Graphiola* Poit. is no longer considered to belong to this suborder; and *Cerebella* Ces. is considered by Saccardo (1886) to be an Hyphomycete.

KEY TO GENERA.

Spores single, not in balls.
  Sori pulverulent at maturity.
    Sori naked at maturity.
      Elaters absent from the sori.
        Probasidia usually with lateral conidia .. 1. *Ustilago*.*
        Probasidia usually with terminal conidia .. 5. *Tilletia*.*
      Elaters present in the sori .. .. .. 2. *Elateromyces*.
    Sori enclosed within a definite fungous membrane .. 4. *Sphacelotheca*.
  Sori compact.
    Central columella of host-tissue present in the sorus .. 3. *Cintractia*.
    Central columella absent .. .. 5. *Tilletia*.*
Spores aggregated into balls.
  Sterile cells present .. .. 7. *Urocystis*.
  Sterile cells absent .. .. 6. *Sorosporium*.

* There is really no satisfactory key character upon which to separate these two genera; for the characters upon which separation is based, see under the respective genera.

1. Ustilago (Persoon) Roussel.

Roussl., *Flora Calvados*, ed. 2, p. 47, 1806.

Uredo § *Ustilago* Pers., *Syn. Fung.*, p. 224, 1801. *Ustilagidium* Herzb., in Zopf, *Beitr. Phys. Morph. Org.*, vol. 5, p. 7, 1895.

Sori forming dark-coloured pulverulent spore-masses in various parts of the host, usually in the inflorescences.

Spores single, globose or angular; epispore coloured, smooth or variously sculptured; germinating by a short septate probasidium, which either produces conidia laterally and terminally, or develops directly into an infection hypha.

Distribution: World-wide.

New Zealand species nine, of which three are indigenous and six introduced. The genus is a large one, and contains more species than any other genus in the suborder, for Clinton (1906) records seventy-two for North America. McAlpine (1910) lists nineteen for Australia.

The pulverulent naked sori and single spores serve to separate this from any other genus, with the exception of *Tilletia*. The production of probasidia bearing lateral conidia serves to separate those species of *Ustilago* possessing this character from those of *Tilletia*, which produce probasidia bearing terminal conidia. But in both genera occur certain species in which the method of germination differs in that no conidia are produced, the probasidium developing directly into an infection hypha. With such species it is necessary to seek some other character in order to place them in one or other of these two genera, unless one follows Herzberg and places them in his genus *Ustilagidium*, separated from *Ustilago* on this account. Other characters serving to separate the two genera are spore-size, it being claimed that the spores of *Tilletia* are relatively larger than those of *Ustilago*, and method of spore-formation, those species in which the spores are produced acrogenously being placed in *Tilletia;* if intercalary, in *Ustilago*. The matter would be simplified if the genus *Ustilagidium* were erected to contain those forms in which no conidia are present; but this would necessitate, in order to maintain consistency, the erection of another genus to contain such species as *Ustilago bromivora*, where the method of germination departs considerably from the normal.

In New Zealand, members of this genus have been found only on the Gramineae, but elsewhere they have been recorded on the following additional families: Cyperaceae, Liliaceae, Polygonaceae, Portulaceae, Caryophyllaceae, Oxalidaceae, and Onagraceae.

Spore-formation.—This was first worked out by Fischer von Waldheim (1869). Following their differentiation, gelatinization of the sporiferous hyphae commences, and continues until the lumen of each hypha is almost obliterated, when the hyphae become compacted together and the gelatinized portions fuse, so that a complex gelatinous mass is formed in which it is difficult to discern individual hyphae. These hyphae become divided by transverse septa into short-celled lengths, and in the cells thus formed the spores commence their development, those near the periphery of the mass first attaining to maturity. The gelatinous envelope surrounds the spore during its development, but gradually becomes less conspicuous until at maturity it has entirely disappeared.

Germination.—In the genus three methods may be observed: in *Ustilago Avenae* the probasidium becomes transversely septate, and from it arise numerous lateral and one terminal conidia; in *U. bromivora* the

probasidium is short and usually continuous —although it sometimes becomes two-celled and on this structure is produced a terminal conidium which on germination (in nutrient solution) again produces a probasidium, which in turn gives rise to a conidium; in *U. Tritici* and *U. striaeformis* the probasidium gives rise directly to an infection hypha, conidia being absent.

KEY TO SPECIES OF USTILAGO.

Spores smooth.	
Spores under 6 mmm.* long	*U. comburens.*
Spores over 6 mmm.	
Sori compact, covered with a membrane	3. *U. Jensenii.*
Sori pulverulent, without a membrane	2. *U. levis.*
Spores rough; granular, verruculose, or verrucose.	
Spores somewhat coarsely verrucose.	
Sori principally in the leaves	5. *U. striaeformis.*
Sori principally in inflorescences.	
Sori semi-compact	7. *U. bullata.*
Sori pulverulent	6. *U. bromivora.*
Spores minutely verruculose.	
Spores over 10 mmm.	9. *U. Readeri.*
Spores under 10 mmm.	
Sori destroying entire inflorescences	4. *U. Tritici.*
Sori semi-compact, only partially destroying spikelets	1. *U. Avenae.*

1. Ustilago Avenae Jensen. (Text-fig. 2, and Plate 41, fig. 2.)

Gramineae.

Jens., *Charb. Cereales*, p. 4, 1889.

U. perennans Rostr., *Overs K. Danske Vid. Selsk. Forh. 1890*, p. 15, 1890.
Cintractia Avenae Ell. et Tr., *Jour. Myc.*, vol. 6, p. 77, 1890.

Sori in spikelets, seldom in the leaves, usually completely destroying the floral parts, forming a pulverulent, olivaceous spore-mass, which eventually falls away, leaving only the bare axis of the inflorescence.

Spores globose or subglobose, 5–9 mmm. diam.; epispore distinctly but finely verruculose, pallid olive, more lightly coloured on one side, 0·5–0·75 mmm. thick.

Host: *Arrhenatherum elatius* (L.) Beauv. In inflorescences. Herb. No. 1247. Plimmerton (Wellington), sea-coast, *E. Bruce Levy!* 22 Dec., 1920. *E. H. Atkinson!* 1 Dec., 1921. Ashburton (Canterbury), 70 m., *H. H. Allan!* 15 Dec., 1921. Crookston; Dunrobin (Otago), *J. C. Neill! G. H. C.* 7 Feb., 1924.†

Distribution: World-wide.

The form on *Arrhenatherum elatius* was separated as a distinct species on account of the presence of perennating mycelium in the perennial parts of the host; it is identical morphologically with the form on the oat, so that it cannot be considered as more than a biologic race.

Germination.- In water the spores commence to germinate in from twelve hours (fresh material) to three days (old material). A long and slender probasidium (occasionally two) is produced; into this the protoplasm of the spore penetrates, and after the probasidium has attained a length several times that of the diameter of the spore several (3–5) transverse septa appear. On or near these septa several elliptical, hyaline, minute, continuous conidia appear. When detached these may in turn germinate and produce long and narrow infection hyphae. In nutrient solution, according to Brefeld (1883), the conidia do not produce hyphae, but produce secondary or tertiary conidia by a process of budding.

* In this article the contraction "mmm." is used for micromillimetres.

† A few localities obtained between the dates of reading the paper and publication have been inserted.

Infection. -This was first studied by Brefeld, who found infection occurred only in the seedling stage of the host. He sprayed budding conidia on to the seedling leaves at different stages of growth; those plants which had attained a development of the leaf beyond the sheathing-leaf were found to be immune. The conidia germinated and produced an infection hypha which penetrated the cuticle and entered the parenchyma, where it produced numerous colourless branched hyphae. As the plant increased in size he found the hyphae increasingly difficult to trace, until at maturity he was able to locate them only in the nodes, where they appeared to be fragmentary and much broken up. Apparently only those hyphae situated in or near the growing-point are able to infect the ovules in the developing inflorescence.

Thus the fungus is transmitted by spores lodged on the seed, between the glume and the pale. When the seed is sown the spores germinate and infect the emerging cotyledon, as described above.

Von Liebenberg (1879) has shown that the spores, if kept under dry conditions, may remain viable for seven years; so that seed stored for several years, if sown without preventive treatment, may bear spores capable of infecting the young plants as they emerge. A second method of infection is known—that of infection from spores remaining in the soil from a previously infected crop. This source is scarcely likely to be troublesome here, for, judging from the readiness with which spores germinate in water, it is probable that with our rainfall such spores would have germinated long ere the seed-bed was prepared for a second crop.

Zade (1922) found that if spores were applied to the inflorescences at the time of flowering, all that fell on the stigmas germinated, producing long probasidia, which in turn produced abundant conidia. When the conidia germinated they produced infection hyphae which gave rise to a mycelium in the peripheral parenchyma of the glumes, the embryo remaining unaffected. He believes this mycelium, and the secondary conidia produced from the hyphae on the inner surface of the glumes, to form the most important source of infection. If this regularly occurs, then dipping of the seed in some fungicide prior to sowing would be useless as a controllant, for the solution used would be unable to penetrate into the glumes to destroy the perennating mycelium therein. In such a case the modified hot-water treatment alone would be of use (see p. 400).

2. Ustilago levis Magnus. (Text-fig. 1, and Plate 41, fig. 1.)

Magn. *Abh. Bot. Ver. Prov. Brand.*, vol. 37, p. 69, 1896.

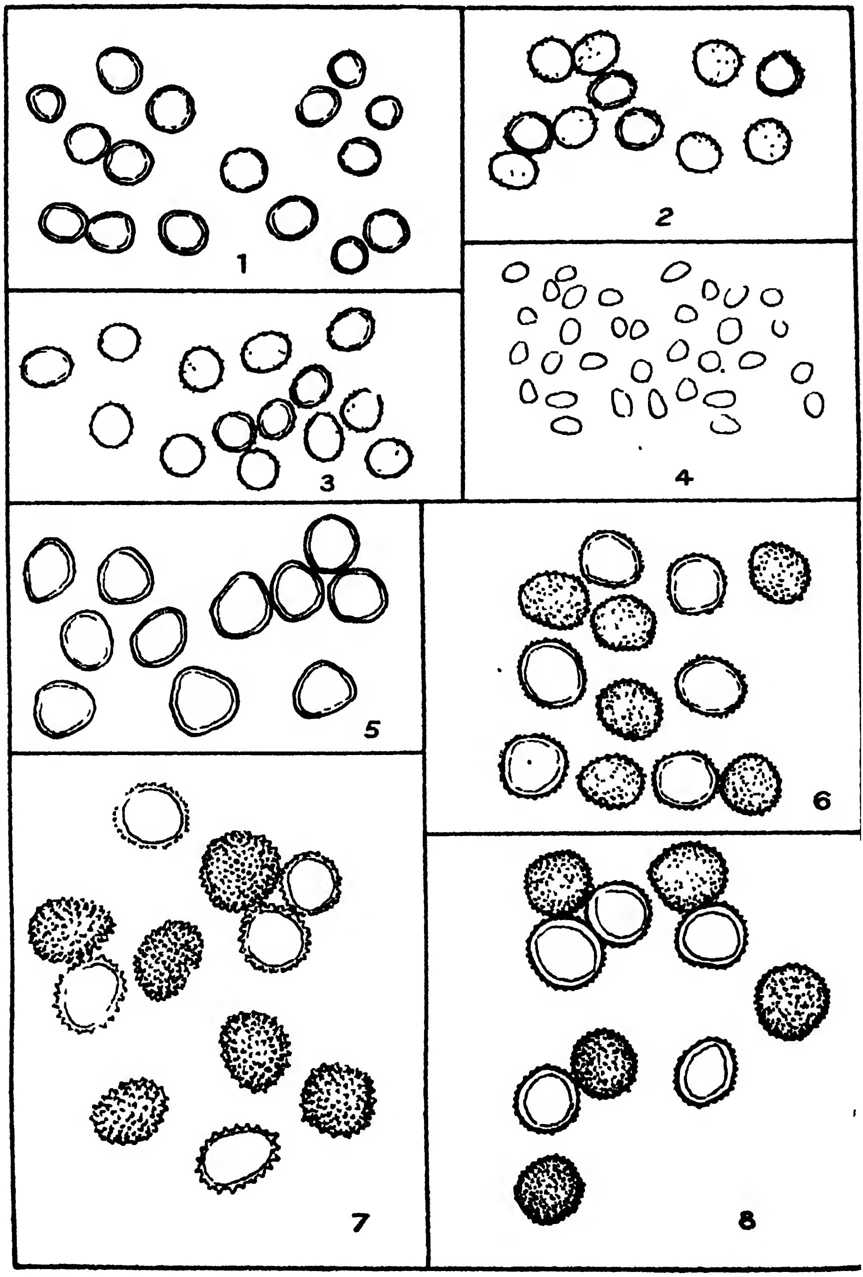
U. Avenae var. *levis* Kell. et Sw., *Ann. Rep. Kansas Exp. Stn., 2nd Rep.*, p. 259, 1890.

Sori in spikelets, destroying the inner parts, partially concealed within the glumes, forming a semi-compact, dark-brown, almost black spore-mass.

Spores subglobose, 5–9 mmm.; epispore smooth, dark chestnut-brown, more lightly coloured on one side, 0·75 mmm. thick.

Host: *Avena sativa* L. In inflorescences. Herb. Nos. 195, 304. Weraroa (Wellington), 80 m., *E. Bruce Levy!* 12 Jan., 1920. Ruakura (Auckland), 120 m., *A. H. Cockayne!* 27 Jan., 1921. Lincoln (Canterbury), 30 m., *F. E. Ward!* 18 Feb., 1921.

Distribution: Probably world-wide, but recorded only from North America and Europe.



TEXT-FIG. 1.—*Ustilago levis* Magn., from *Avena sativa* L.
TEXT-FIG. 2.—*U. Avenae* Jens., from *Arrhenatherum elatius* (L.) Beauv.
TEXT-FIG. 3.—*U. Tritici* Jens., from *Triticum vulgare* Vill.
TEXT-FIG. 4.—*U. comburens* Ludw., from *Danthonia Buchanani* Hook. f.
TEXT-FIG. 5.—*U. Jensenii* Rostr., from *Hordeum vulgare* L.
TEXT-FIG. 6.—*U. bullata* Berk., from *Agropyron scabrum* Beauv.
TEXT-FIG. 7.—*U. striaeformis* (Westnd.) Niessl, from *Holcus lanatus* L.
TEXT-FIG. 8.—*U. bromivora* (Tul.) Fisch. v. Waldh., from *Bromus unioloides* H. B. K.

All × 1,000.

This species is abundant throughout New Zealand. It is separated from the preceding on account of the smooth epispores of the spores. The sori also differ somewhat in their being more compact.

Germination, life-history, and control are the same as in *U. Avenae.*

3. **Ustilago Jensenii** Rostrup. (Text-fig. 5, and Plate 42, fig. 2.)

Rostr., *Overs. K. Danske Vid. Selsk. Forh. 1890*, p. 12, 1890.

Uredo Hordei var. *tecta* Jens., *Charb. Cereales*, p. 4, 1889. *Ustilago Hordei* Kell. et Sw., *Ann. Rep. Kansas Agr. Exp. Stn., 2nd Rep.*, p. 268, 1890.

Sori in spikelets, forming a semi-compact black mass, long covered by the transparent basal parts of the glumes.

Spores globose to shortly elliptical, 7–11 × 5–8 mmm.; epispore smooth, olivaceous or sepia-brown, more lightly coloured on one side, 0·75–1 mmm. thick.

Host: *Hordeum vulgare* L. In inflorescences. Herb. Nos. 298, 1253. Ruakura (Auckland), 120 m., *A. H. Cockayne!* 25 Jan., 1921. Blenheim (Marlborough), 50 m., *J. Scott!* 28 Feb., 1921. Winton (Otago), *J. C. Neill!* 14 Feb., 1924.

Distribution: Australia; North America; Europe.

This is known as the "covered smut of barley," on account of the manner in which the sori are covered by the basal portions of the glumes. It is common on this host throughout New Zealand.

This species, together with *U. Avenae*, *U. levis*, and *U. Tritici*, were at one time included under the collective species *U. segetum* Dittm. Jensen (1889A), as the result of numerous infection experiments, split *U. segetum* into three races, as follows: (1) *U. segetum* var. *Avenae*; (2) *U. segetum* var. *Tritici*; (3) *U. segetum* var. *Hordei.* The variety *Hordei* he further divided into the two forms: *U. segetum* var. *Hordei* forma *nuda*; *U. segetum* var. *Hordei* forma *tecta.*

Brefeld (1888) considered the forms on barley and on wheat to be distinct, for he found the probasidium did not produce conidia, but gave rise directly to an infection hypha. He found also that these races would not infect oats; consequently he considered them to be distinct from the form on oats, and included them under the name of *U. Hordei* Bref. In his species are included *U. segetum* var. *Tritici* Jens. and *U. segetum* var. *Hordei* Jens. (including the two forms *nuda* and *tecta*).

Kellerman and Swingle (1890) raised to specific rank the two forms on barley—*nuda* and *tecta*—naming them respectively *U. nuda* (Jens.) Kell. et Sw., and *U. Hordei* (Pers.) Kell. et Sw. Thus Brefeld's *U. Hordei* was split by them into three species—(1) *U. Tritici* (Jens.) Kell. et Sw.; (2) *U. Hordei* (Pers.) Kell. et Sw.; (3) *U. nuda* (Jens.) Kell. et Sw.

Now, as the name *Hordei* was previously used by Brefeld, it cannot again be applied to a species; as *U. Hordei* of Kellerman and Swingle was named *U. Jensenii* by Rostrup the same year, this name should be used for this species. The matter is further complicated in that although the forms *tecta* and *nuda* are morphologically separable, and may therefore be considered as distinct species, the form *nuda* (*U. nuda* Kell. et Sw.) is identical morphologically with *U. Tritici* Jens., for both possess pulverulent sori, echinulate spores of the same size and colour, and the same method of germination. After extended and critical examination of these two so-called species I am unable to indicate a single morphological character by which they may be separated. True, in certain collections the spore-mass is slightly darker in colour on wheat than on barley, but this character is not distinct in all collections.

I am of the opinion, therefore, that *U. Tritici* Jens. and *U. nuda* Kell. et Sw. must be reunited under one name. As to the selection of this name: *U. segetum* cannot, of course, be used, nor can *U. Hordei* Bref., for this included the recognized species *U. Jensenii* Rostr. and the one under discussion. *U. Tritici* Jens. was by Kellerman and Swingle described on page 262; *U. nuda* Kell. et Sw. on page 277: since the former has page priority, it is the one to be used.

Clinton (1906) gives the citation of this species as *U. Tritici* (Pers.) Rostr., but the specific name used by Rostrup is taken from *Uredo segetum* var. *Tritici* Persoon, in *Tent. Disp. Fung.*, p. 57, 1797, a publication which antedates the starting-point of modern nomenclature.

The four species under discussion may then be separated by the following characters:—

Probasidium producing conidia.
  Sori pulverulent.
    Spores echinulate .. .. *U. Avenae* Jens.
    Spores smooth .. .. *U. levis* Magn.
  Sori compact .. .. *U. Jensenii* Rostr.
Probasidium producing an infection hypha, conidia being absent *U. Tritici* Jens.

Germination and infection (of *U. Jensenii*) are similar to the preceding two species.

4. **Ustilago Tritici** Jensen. (Text-fig. 3, and Plate 42, fig. 1.)

Jens.: Kell. et Sw., in *Ann Rep. Kansas Agr. Exp. Stn.*, *2nd Rep.*, p. 622, 1890.

Ustilago segetum var. *Tritici* Jens., *Om. Korns. Brandp.*, p. 61, 1888. *U. segetum* var. *Hordei* forma *nuda* Jens., *Jour. Roy. Agr. Soc.*, vol. 24, p. 4, 1889. *U. Hordei* var. *nuda* Jens., *Charb. Cereales*, p. 4, 1889. *U. nuda* (Jens.) Kell. et Sw., *Ann. Rep. Kansas Exp. Stn.*, *2nd Rep.*, p. 277, 1890. *U. Tritici* (Pers.) Rostr., *Overs. K. Danske Vid. Selsk. Forh. 1890*, p. 15, 1890. *U. Hordei* Rostr., *l.c.*, p. 10. *U. Tritici* forma *foliicola* P. Henn., *Zeitschr. Pflanzenkr.*, vol. 4, p. 139, 1894. *Ustilagidium Hordei* Herzb., in Zopf, *Beitr. Phys. Morph. Org.*, vol. 5, p. 7, 1895. *U. Tritici* Herzb., *l.c.*

Sori in spikelets, destroying ovaries and glumes, forming olivaceous or almost black spore-masses, finally falling away and leaving the bare axis of the inflorescence.

Spores globose to shortly elliptical, 5–8 × 4 5 mmm; epispore minutely but distinctly verruculose, pallid to dark olive, with a lighter-coloured zone on one side, 0·5–0·75 mmm. thick.

Hosts:

Triticum vulgare Vill. In inflorescences. Herb. No. 407. Lincoln, Canterbury, 30 m., *F. E. Ward!* 5 March, 1921.

Hordeum vulgare L. In inflorescences. Herb. No. 46. Weraroa, (Wellington), 120 m., *G. H. C.* 11 Nov., 1919.

Distribution: World-wide.

The form on wheat is commonly known as "naked smut on wheat" that on barley as "naked smut of barley." As has been pointed out (under *U. Jensenii*), the two forms differ only in that each is confined to its host, but as they are identical in morphological characters they must be considered as the same species.

The two species on barley may be separated on account of the following differences:—

Sori compact; spores smooth .. .. .. *U. Jensenii.*
Sori pulverulent; spores verruculose .. .. *U. Tritici.*

Germination.—In water a probasidium is produced which gives rise directly to an infection hypha; this may branch and form a mycelium, but does not at any time produce conidia.

Infection.—With the race on barley it was first suggested by Jensen (1889B), and later independently confirmed by Hecke (1905), that infection occurs through the flower. With the race on wheat Maddox (1897) first demonstrated that infection occurred through the flower; his work was later confirmed by Brefeld (1903). The spores are deposited by wind on the stigmas at the time of pollination, where they germinate and produce a probasidium, which develops immediately into an infection hypha; this penetrates the style and enters the cells of the developing ovary, where a mycelium is formed. As the embryo commences to develop, hyphae pass into it and form a resting mycelium, which remains latent until such time as the grains germinate. When germination commences these hyphae grow out with the cotyledon, keeping pace with the growing-point until the formation of the inflorescence, when they penetrate to the developing ovaries. These they convert—together with the developing ovules—into a mass of mycelium, which later produces the spores.

The significance of this life-history, from the viewpoint of the farmer, is that the resting mycelium is embedded in the tissues of the grain, where it cannot be reached by fungicides; consequently the disease cannot be controlled by the usual steeping methods. Freeman and Johnson (1909) claim to have successfully combated this smut by means of Jensen's modified hot-water treatment (see p. 400).

5. **Ustilago striaeformis** (Westendorp) Niessl. (Text-fig. 7, and Plate 46, fig. 2.)

Niessl, *Hedw.*, vol. 15, p. 1, 1876.

Uredo striaeformis Westnd., *Acad. Roy. Belgique, Bull. 18*, ser. 2, p. 406, 1852. *Tilletia De Baryana* Fisch. v. Waldh., in Rabh. *Fungi Eur., No. 1097*, 1866. *T. Milii* Fcl., *Symb. Myc.*, vol. 1, p. 40, 1869. *T. striaeformis* Oud., *Bot. Ztg.*, vol. 36, p. 440, 1878. *T. alopecurivora* Ule, *Bot. Ver. Prov. Brandenburg*, vol. 25, p. 214, 1884. *T. Brizae* Ule, *l.c.* *Ustilago Poarum* McAlp., *Proc. Roy. Soc. Vic.*, n.s., vol. 7, p. 220, 1894. *U. washingtoniana* Ell. et Ev., *Bull. Torrey Cl.*, vol. 22, p. 57, 1895. *Tilletia Airae-caespitosae* Lindr., *Soc. pro Fauna et Flora Fennica*, vol. 26, p. 15, 1904.

Sori rarely in the inflorescences, commonly in the leaves and leaf-sheaths, forming long striae often many centimetres in length, frequently converging to form irregular black areas, at first covered by the epidermis, becoming exposed and pulverulent, finally in old specimens the leaves becoming shredded; in inflorescences the sori are frequently hidden within the glumes, but eventually become pulverulent and partially exposed.

Spores globose to shortly elliptical, often somewhat angular, 10–17 × 8–12 mmm.; epispore moderately and somewhat coarsely verrucose, olive-brown, 1 1·5 mmm. thick.

Hosts:—

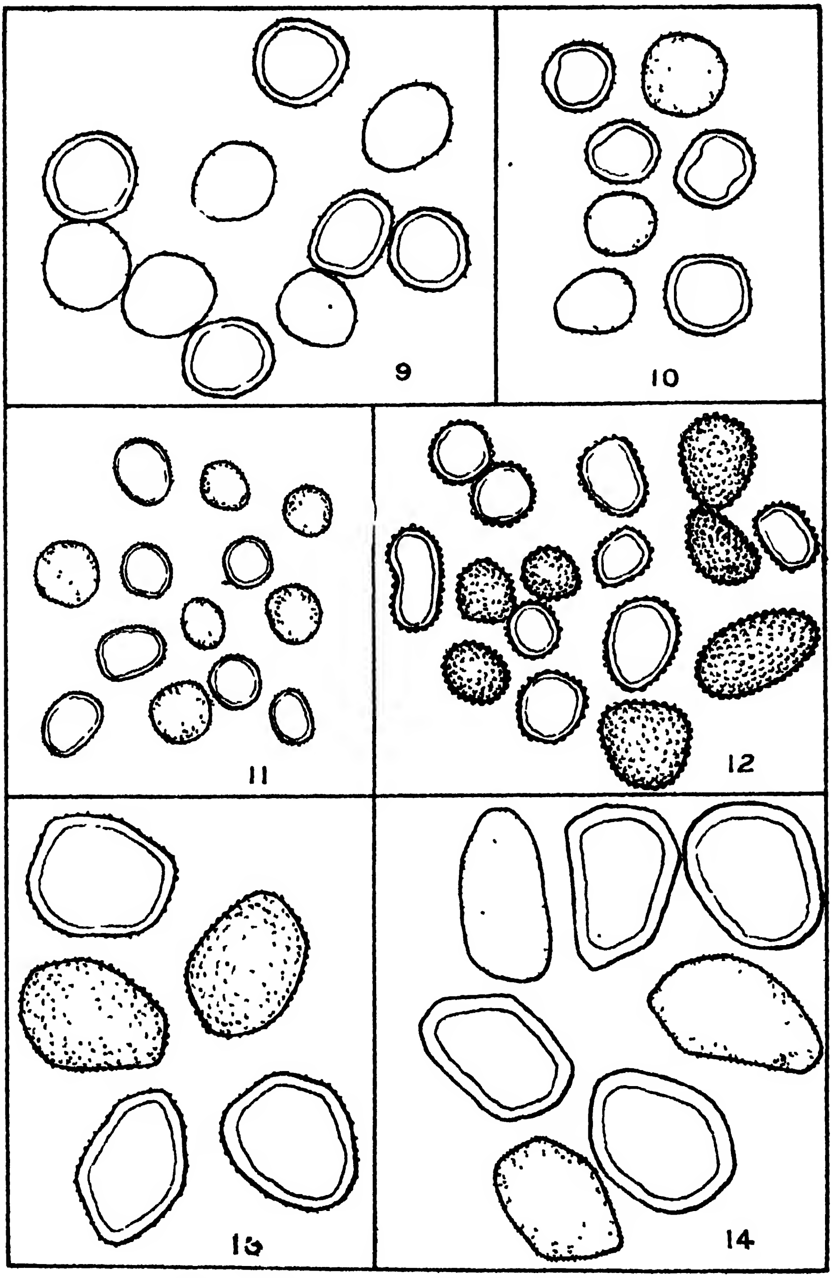
Dactylis glomerata L. In leaves and sheaths. Herb. No. 265. Cluny, Turakina (Wellington), 210 m., *G. H. C.* 2 Jan., 1921.

Holcus lanatus L. In leaves. Herb. No. 1276. Ettrick (Otago), 300 m., *R. B. Tennent!* 10 Feb., 1921. Karori (Wellington), 200 m., *R. Waters!* 6 Dec., 1923.

Distribution: World-wide.

This species is readily recognized by the manner in which the infected leaves become shredded, tearing occurring along the linear sori. Infected plants are usually stunted, and not infrequently killed outright.

Germination.—Osner (1916) has well illustrated the method of germination. A short probasidium is produced, and this grows directly into an infection hypha; no conidia are produced.



TEXT-FIG. 9.—*Ustilago Readeri* Syd., from *Danthonia pilosa* R. Br.
TEXT-FIG. 10.—*Sphacelotheca Hydropiperis* (Schum.) De Bary, from *Polygonum* sp.
TEXT-FIG. 11.—*Elateromyces niger* G. H. Cunn., from *Carex dipsacea* Berggr.
TEXT-FIG. 12.—*E. olivaceus* (DC.) Bubak, from *Carex virgata* Sol.
TEXT-FIG. 13.—*Cintractia sclerotiformis* (C. & M.) G. H. Cunn., from *Uncinia riparia* R. Br.
TEXT-FIG. 14.—*C. Caricis* (Pers.) Magn., from *Carex ternaria* Forst. f.

All × 1,000.

Infection. According to Osner, healthy plants become infected through the flowers, as is the case with wheat or barley infected with *U. Tritici.* Following infection the hyphae remain quiescent in the seed until they germinate, when they grow out with the developing leaves and stems. These hyphae give rise to the linear sori; those that grow with the growing-point of shoots producing inflorescences infect the ovaries as they are formed. The mycelium also hibernates in the roots of perennial plants, and infects developing shoots as they emerge in the spring. Osner points out that the disease may be combated by means of the modified hot-water treatment (p. 400), but this would prevent only young plants (seedlings) from becoming infected, for, since he has shown the mycelium to be perennial in perennial plants, it follows that once such a plant has become infected nothing in the way of remedial treatment can be attempted.

The species is placed by the majority of systematists in the genus *Tilletia*, largely on account of the work of Fischer von Waldheim (1869), who claimed the method of spore-formation was that of this genus. Osner, however, has shown that spore-formation is intercalary in the spore-forming hyphae, and that this "adds weight to the contention that the organism is a species of *Ustilago* rather than of *Tilletia.*" He mentions the appearance of transverse septa in the probasidium as another character in support of placing the species in *Ustilago.* This, however, is of little significance, since these septa also appear in the probasidia of *Tilletia.*

6. **Ustilago bromivora** (Tulasne) Fischer von Waldheim. (Text-fig. 8, and Plate 43, fig. 1.)

F. v. Waldh., *Bull. Soc. Nat. Mosc.*, vol. 40, p. 252, 1867.

Ustilago Carbo var. *vulgaris* d. *bromivora* Tul., *Ann. Sci. Nat.*, ser. 3, vol. 7, p. 81, 1847. *Cintractia patagonica* Cke. et Mass., *Grev.*, vol. 18, p. 34, 1889.

Sori in spikelets, often hidden within the glumes, sometimes destroying them at the base, at first bullate and somewhat compacted, becoming pulverulent, black.

Spores globose to shortly elliptical, often polygonal, 8–11 × 7–10 mmm; epispore minutely but densely verrucose, olivaceous or dark reddish-brown, 1 mmm. thick.

Hosts:

Bromus hordeaceus L. In panicles. Herb. No. 442. Blenheim (Marlborough), 30 m., *F. Sisson!* 12 Nov., 1920.

Bromus unioloides H. B. K. Herb. No. 47. Weraroa (Wellington), 120 m., *G. H. C.* 11 Dec., 1919. Omahu, Thames Valley (Auckland), *W. G. Goodwin!* 22 Nov., 1921. Blenheim (Marlborough), 30 m., *R. Waters!* 27 Nov., 1923. Lincoln (Canterbury), 30 m., *F. E. Ward!* 3 Dec., 1923.

Distribution: World-wide.

The species is fairly abundant on prairie-grass throughout New Zealand. In many cases only occasional spikelets may be infected, but as a rule all on a panicle are attacked.

Germination.—In water the spores readily germinate, producing a small probasidium, on the apex of which is produced a single elliptical conidium. In nutrient solution, according to Brefeld (1883), a two-celled probasidium is formed; this produces conidia, which in turn develop a probasidium again producing conidia.

Infection occurs in a manner similar to *U. Avenae.* McAlpine (1910) states that treating the seed with formalin or copper-sulphate effectively controls this smut.

7. Ustilago bullata Berkeley. (Text-fig. 6, and Plate 42, fig. 3.)

Berk., *Fl. N.Z.*, vol. 2, p. 196, 1855.

Sori in inflorescences, at first enclosed in a lead-coloured membrane, when semi-compact, becoming exposed, when pulverulent, black.

Spores globose to shortly elliptical, 8–12 × 7–8 mmm.; epispore closely and finely verrucose, olivaceous, 1 mmm. thick.

Host: *Agropyron scabrum* (Lab.) Beauv. In inflorescences. North Island, *W. Colenso.* 1849. (Type in Herb. Kew.)

Distribution: Australia.

The host is indigenous and widespread; it occurs also in Australia (Cheeseman, 1906, p. 923).

This species was described by Berkeley from material forwarded by Colenso to Kew. I have no New Zealand material in the herbarium, the above description being drawn up from Australian material kindly forwarded by Mr. C. C. Brittlebank, Plant Pathologist, Department of Agriculture, Melbourne.

Germination.—McAlpine (1910, p. 152) has successfully germinated the spores of this species. He found that in water the probasidium became three-celled, the proximal cell eventually developing into a well-developed infection hypha; no conidia were produced, but in nutrient solution a probasidium was produced, which gave rise to numerous conidia.

8. Ustilago comburens Ludwig. (Text-fig. 4, and Plate 41, fig. 3.)

Ludw., *Zeitschr. Pflanzenkr.*, vol. 3, p. 139, 1893.

Ustilago microspora Mass. et Rodw., *Kew Bull.*, p. 160, 1901. *U. exigua* Syd., *Ann. Myc.*, vol. 1, p. 177, 1903.

Sori in spikelets and stems, at first compact, bullate, and covered with a lead-coloured membrane, later destroying the entire panicle and becoming exposed on the rachis as a dense bronze pulverulent mass, eventually falling away, leaving the naked axis.

Spores globose to shortly elliptical, 3–5 × 2–3 mmm.; epispore smooth, tinted olive, 0·5 mmm. or less in thickness.

Host: *Danthonia Buchanani* Hook. f. In panicles. Herb. No. 197. Dunstan Mountains (Otago), 350 m., *W. D. Reid!* 6 Dec., 1921.

Distribution: Australia.

The host is endemic, and is confined to the mountain regions of the South Island (Cheeseman, 1906, p. 891).

The species is characterized by the exceedingly minute size of the spores. It was first recorded on a species of *Stipa*, but McAlpine (1910, p. 154), who has examined portion of the type material, states that the host in question is a species of *Danthonia*.

I have been unable to germinate the spores.

9. Ustilago Readeri Sydow. (Text-figs. 9, 27, and Plate 43, figs. 2, 3.)

Syd. *in letter;* McAlp., *Smuts. Austr.*, p. 159, 1910.

Ustilago Agropyri McAlp., *Ag. Gaz. N.S.W.*, vol. 7, p. 154, 1896.

Sori in spikelets, stems, and leaves, commonly destroying the entire inflorescence. On stems and leaves forming conspicuous striae; in inflorescences, at first enclosed within the leaf-sheath, becoming exposed and appearing in the form of semi-compact masses covered with the remnants of the glumes, when greyish in colour, at length naked, pulverulent, black, finally falling away leaving the bare axis.

Spores globose to shortly elliptical, 11–14 × 8–12 mmm.; epispore minutely and closely verruculose, dark brown, 1–1·5 mmm. thick.

Hosts:—

Danthonia pilosa R. Br. In panicles, stems, and leaves. Herb. Nos. 782, 1267. Mount Hector, Tararua Mountains (Wellington), 1,600 m., *E. H. Atkinson!* 21 Dec., 1919. Plimmerton (Wellington), sea-shore, *E. H. Atkinson!* 1 Dec., 1921. Kelburn (Wellington), 120 m., *G. H. C.* 23 Nov., 1922; 4 Dec., 1923.

Danthonia semiannularis R. Br. Herb. No. 200. Whitianga (Hawke's Bay), *Shelford-Bidwell!* 18 Dec., 1920. Otane (Auckland), *H. F. Nunn!* 3 Mar., 1922. Botanical Gardens (Wellington), 80 m., *G. H. C.* 19 Jan., 1921. *J. C. Neill! G. H. C.* 4 Dec., 1923.

Anthoxanthum odoratum L. Herb. No. 1248. Wallaceville (Wellington), 30 m., *F. E. Ward!* 5 Dec., 1920.

Distribution: Australia.

Both species of *Danthonia* are indigenous and abundant throughout; they occur also in Australia (Cheeseman, 1906, p. 890). This smut has hitherto been recorded only on *Danthonia*, *Anthoxanthum* being an additional host.

This is the most abundant of all species of the Ustilaginaceae occurring in New Zealand, and appears season after season in the same locality. *U. Agropyri* McAlp. was based on a mixture of material of *Agropyron* and *Danthonia*, which was afterwards separated out.

Germination.—In water germination occurs within twenty-four hours, probasidia bearing abundant conidia being produced; frequently the conidia are borne on short sterigmata. In nutrient solution the conidia produce secondary conidia by budding.

2. Elateromyces Bubak.

Bubak, *Archiv. pro Prirodovedecky Vyzkum Cech*, dil. 15, C. 3, p. 32, 1912.

Sori semi-compact, dark-coloured, usually confined to the inflorescences.

Spores single, globose to angular, smooth or verruculose, mixed with numerous coloured filaments (elaters) formed of numerous hyphae arranged in parallel fashion; germination by means of an elliptical probasidium, which becomes detached as a conidium.

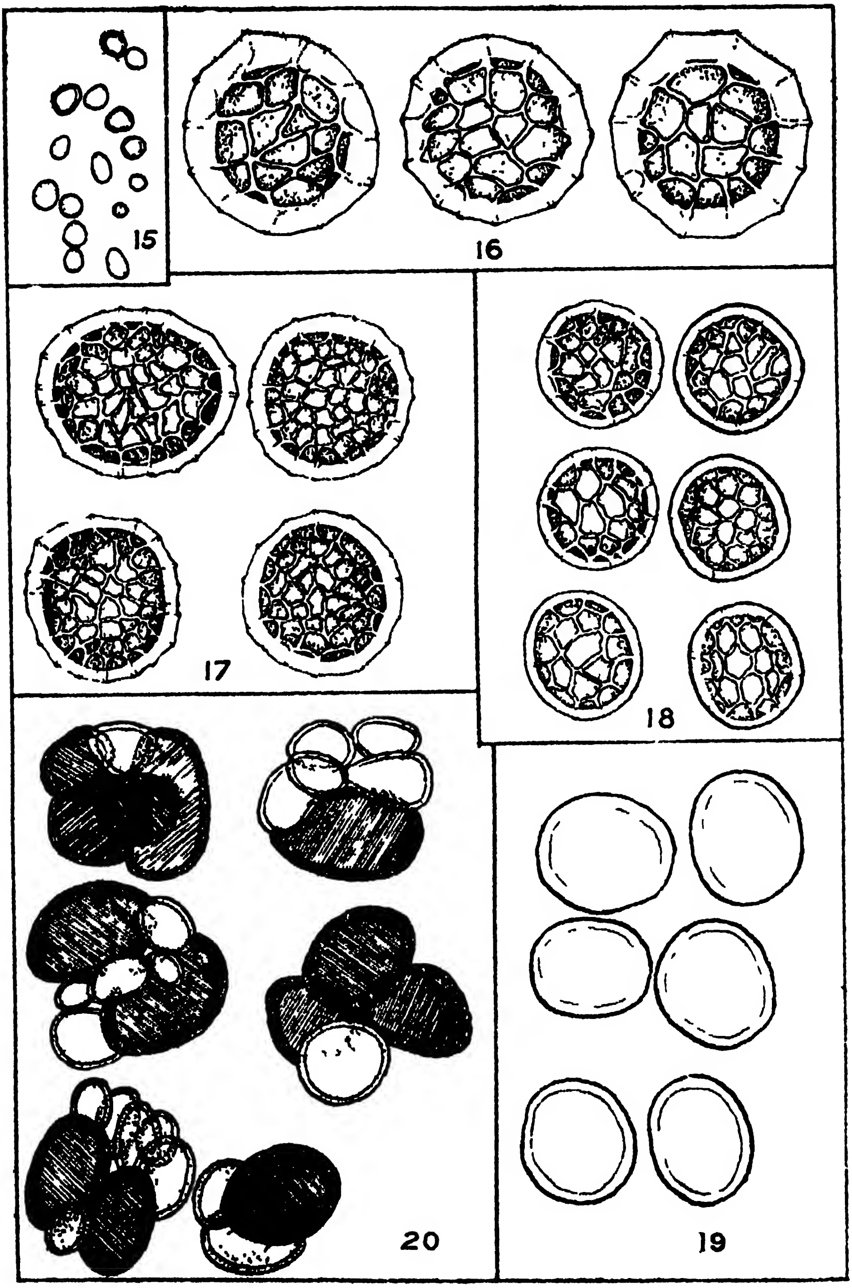
Distribution: World-wide.

Of the three New Zealand species, two are endemic, and the third is indigenous, being widely distributed elsewhere.

This genus was erected by Bubak on account of the presence in the sori of numerous peculiar filaments, or "elaters," as he has termed them. These elaters consist of numerous coloured hyphae arranged in a parallel manner. The hyphae are septate, and are 5–8 mmm. in thickness; the elaters may attain a length of 22 mm., but usually they are much shorter than this, being on an average 8–10 mm. long; in thickness they vary from 40 to 120 mmm. or even more. They are so characteristic that I have no hesitation in following Bubak and placing those New Zealand species possessing these structures in this genus. Their function is unknown, but they are supposed to assist in spore-distribution.

The method of germination is discussed under *E. olivaceus* and *E. niger*.

The three New Zealand species are confined to the Cyperaceae, two being parasitic on *Carex*, the third on *Gahnia*. Bubak records another species in addition to *E. olivaceus*—*E. Treubii* (Solms.) Bubak (= *Ustilago*



TEXT-FIG. 15.—*Cintractia Spinificis* (Ludw.) McAlp., from *Spinifex hirsutus* Lab.
TEXT-FIG. 16.—*Tilletia Holci* (Westnd.) Rostr., from *Holcus lanatus* L.
TEXT-FIG. 17.—*T. decipiens* (Pers.) Koern, from *Agrostis vulgaris* With.
TEXT-FIG. 18.—*T. Tritici* Wint., from *Triticum vulgare* Vill.
TEXT-FIG. 19.—*T. levis* Kuehn, from *Triticum vulgare* Vill.
TEXT-FIG. 20.—*Urocystis Anemones* Wint., from *Ranunculus insignis* Hook. f.

All × 1,000.

Treubii Solms.), on *Polygonum cinense* from Java; but his combination cannot be accepted, for *U. Treubii* is a synonym of *U. emodensis* Berk., according to Massee (1899). I cannot say whether it should be placed in *Elateromyces*, for I have not examined specimens.

KEY TO SPECIES.

Sori olivaceous	3. *E. olivaceus.*
Sori black, or nearly so.	
On *Gahnia*	1. *E. endotrichus.*
On *Carex*	2. *E. niger.*

1. **Elateromyces endotrichus** (Berkeley) n. comb.

Ustilago endotricha Berk., *Fl. N.Z.*, vol. 2, p. 196, 1855.

Sori in inflorescences, elliptical, black, pulverulent, intermixed with numerous long coloured elaters.

Spores globose, 5–7 mmm. diam., epispore minutely and closely verruculose, blackish olive.

Host: *Gahnia* sp. In inflorescences. North Island, *Sinclair*. (Type in Herb. Kew.)

Distribution: New Zealand.

Only the single collection now at Kew (as *Ustilago*) has been made of this species. It is closely related to the following, which may possibly turn out to be the same; I have separated *E. niger* principally on account of the larger spores, and especially the very numerous black elaters.

E. endotrichus has been recorded from Ceylon, but Petch (1912)—to whose paper I am indebted for the description of the spores, given above—states the Ceylon species is *E.* (*Ustilago*) *olivaceus*.

The method of germination is unknown.

2. **Elateromyces niger** n. sp. (Text-figs. 11, 28, and Plate 44, fig. 1.)

Sori in occasional ovaries, at first compact and partially concealed within the perigynium, becoming exposed when semi-pulverulent, black, elliptical, and up to 6 mm. in length; intermixed with very numerous conspicuous elaters, black in mass, blackish-olive individually, which may attain a length of 15 mm. but are commonly less, averaging 10 mm.

Spores globose to shortly elliptical, 6–9 × 5–7 mmm.; epispore minutely and moderately verruculose, dark olive, 0·75 mmm. thick.

Host: *Carex dipsacea* Berggr. In panicles. Herb. No. 311. Pencarrow (Wellington), sea-coast, *E. H. Atkinson!* 10 Feb., 1921. (Type.)

The host is an endemic species, occurring throughout the lowland areas of both Islands (Cheeseman, 1906, p. 822).

This is separated from the following species on account of the smaller and more regular spores, black colour of the sori, elaters, and spores, and the conspicuous elaters. These latter are so numerous as to give the sori a woolly appearance, as if a small tuft of hair had been caught and held in the position occupied by the sorus.

Germination. In water, after three days, a few spores germinated after the material had been kept in the herbarium for twenty-one months. The method of germination is similar to *E. olivaceus*, a small probasidium being produced. This is elliptical in shape, and about the same length as the spore. Shortly after its formation it becomes detached and functions as a conidium. The spores did not germinate when placed in nutrient solution (soil extract).

FIG. 1.—*Ustilago levis* Magn., on *Avena sativa* L.
FIG. 2.—*U. Avenae* Jens., on *Arrhenatherum elatius* (L.) Beauv. Healthy plant on left, smutted plants on right.
FIG. 3.—*U. comburens* Ludw., on *Danthonia Buchanani* Hook. f. Diseased plants in centre; note how completely the inflorescences are destroyed.

Photos by H. Drake. All natural size.

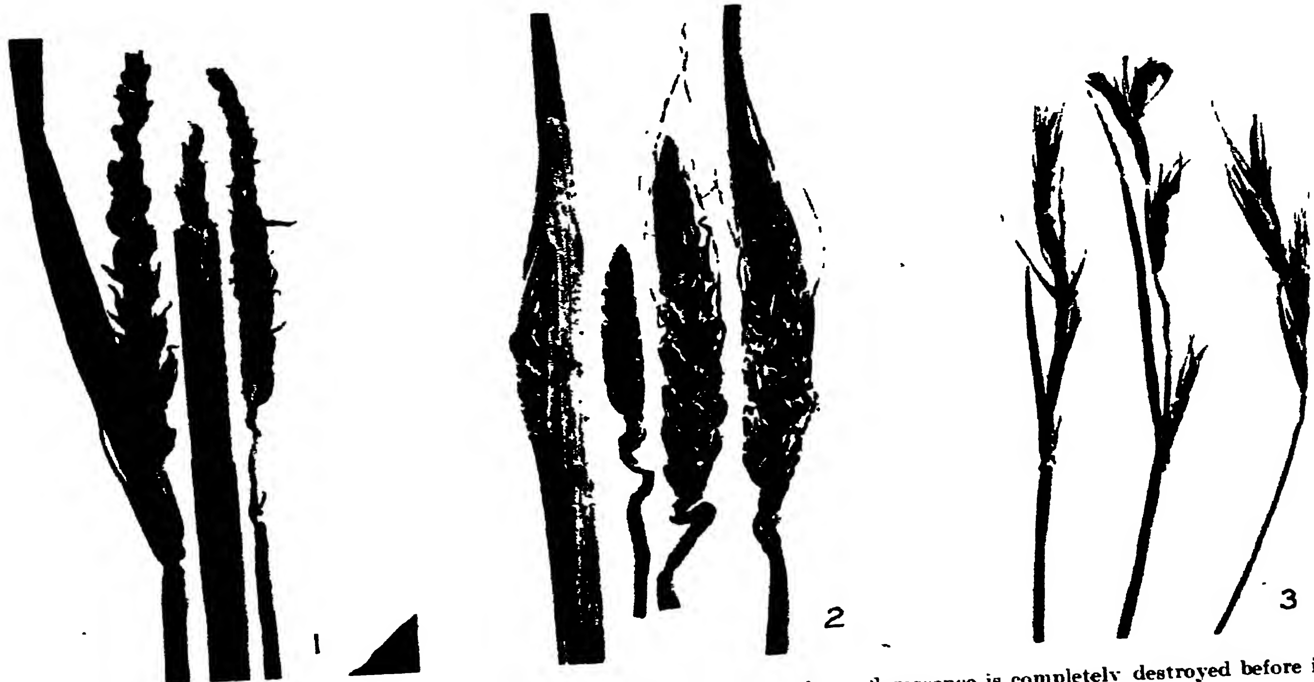


FIG. 1.—*Ustilago Tritici* Jens., on *Triticum vulgare* Vill. Note (in centre) that inflorescence is completely destroyed before it is free from the shot-blade (the latter dissected away to show apical portion of the smutted inflorescence).

FIG. 2.—*U. Jensenii* Rostr., on *Hordeum vulgare* L. Note compact nature of sori, and fact that the inflorescence is destroyed ere it has emerged from the shot-blade (on left). Normal inflorescence on right. Note bullate nature of the sori.

FIG. 3.—*U. bullata* Berk., on *Agropyron scabrum* Beauv.

Photos by H. Drake. All $\frac{3}{4}$ natural size.

FIG. 1.—*Ustilago bromivora* (Tul.) F. v. Waldh., on *Bromus unioloides* H. B. K. Normal inflorescence on the right.
FIG. 2.—*U. Readeri* Syd., on *Anthoxanthum odoratum* L. Normal inflorescence in the centre.
FIG. 3.—*U. Readeri* Syd., on *Danthonia pilosa* R. Br.

Photos by H. Drake. All ¾ natural size.

1

2

FIG. 1. *Elateromyces major* G. H. Cunn., on *Carex dipsacea* Berggr. Reduced to ½.
FIG. 2.—*Cintractia Caricis* (Pers.) Magn., on *Carex* spp. Infected specimen of *Carex Gaudichaudiana* Kunth on left: note the almost spherical nature of the sori. Infected specimens of *Carex ternaria* Forst. f. on the right: note the fusoid nature of the sori, an unusual condition possibly meriting a varietal name. ⅔ natural size.

Photos by H. Drake.

1

2

Fig. 1.—*Cintractia Spinificis* (Ludw.) McAlp., on male (left) and female (right) inflorescences of *Spinifex hirsutus* Lab.
Fig. 2.—*Urocystis Anemones* Wint., on leaf of *Ranunculus insignis* Hook. f.

Photos by H. Drake. Both reduced to ⅔.

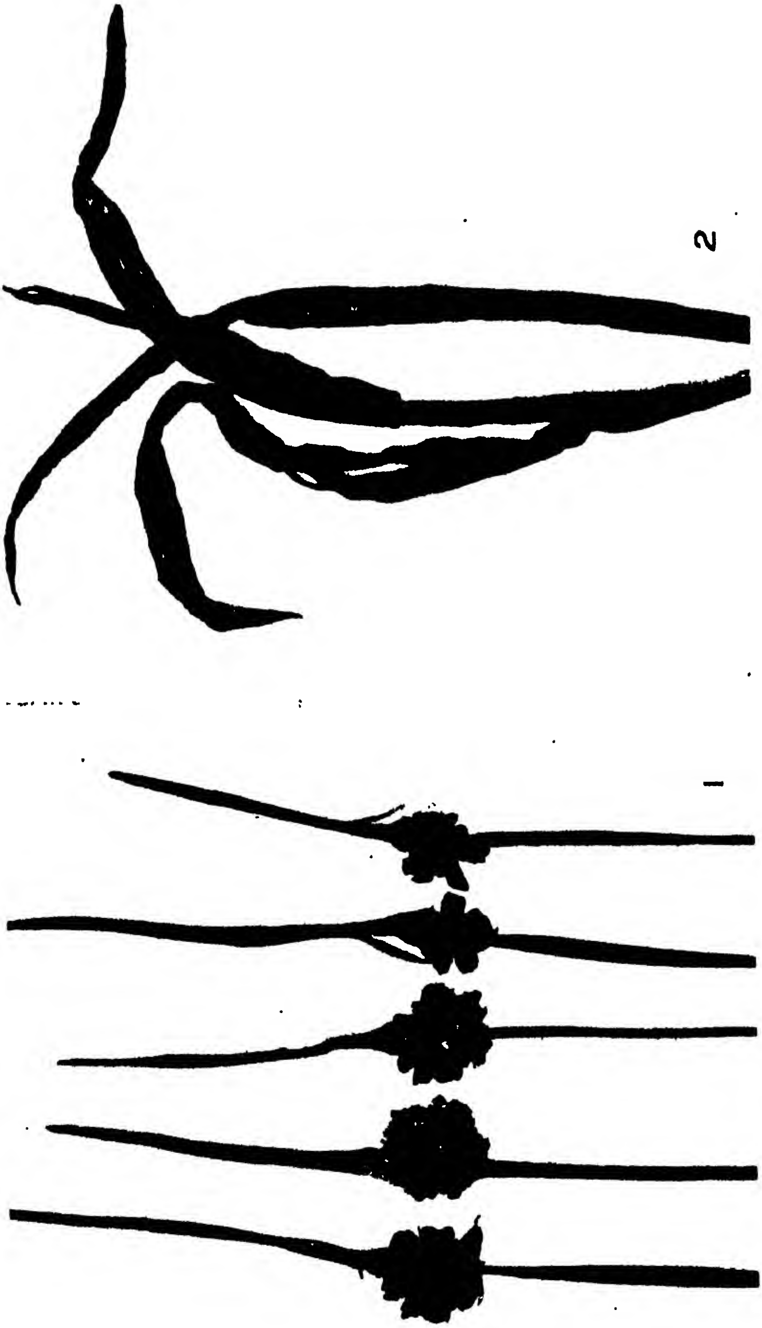


Fig. 1.—*Sorosporium Neillii* G. H. Cunn., in inflorescences of *Scirpus nodosus* Rottb. Slightly infected specimens in the centre.
Fig. 2.—*Ustilago striaeformis* (Westnd.) Niessl, in leaves of *Holcus lanatus* L. Note linear arrangement of sori.

Photos by H. Drake. All natural size.

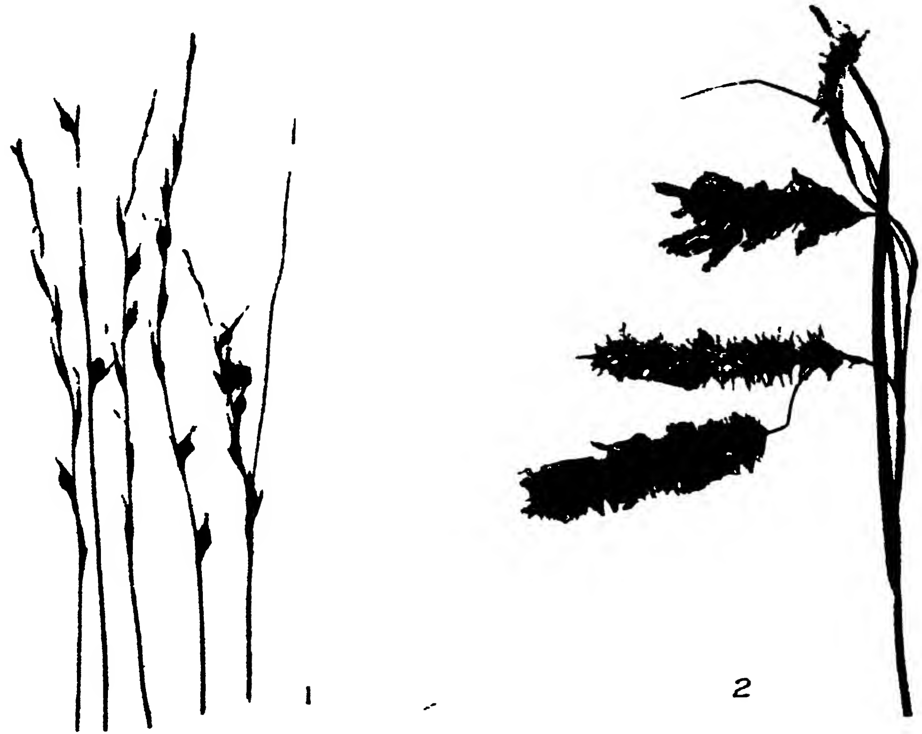


FIG. 1. *Cintractia sclerotiiformis* (C. & M.) G. H. Cunn., in the ovaries of *Uncinia riparia* R. Br. ¾ natural size.
FIG. 2. – *Elateromyces olivaceus* (DC.) Bubak, on *Carex dipsacea* Berggr. Specimen shows abnormal development of elaters. ¾ natural size.

Photos by H. Drake.

[*Latin diagnosis.*]

Elateromyces niger sp. nov.

Soris ad ovaria destruentibus, semi-pulverulentis, atris, ellipticis, ad 6 mm. longis. Fibra intermixto, copioso, atro, 8–15 mm. longo.

Sporis globosulis v. breviter ellipticis, 6–9 × 5–7 mmm.; episporio subtilissime verruculoso, olivaceo, 0·75 mmm. crasso.

Hab.: In ovariis *Caricis dipsaceae* Berggr. Pencarrow (Wellington, N.Z.), sea-coast, *E. H. Atkinson!*

3. **Elateromyces olivaceus** (De Candolle) Bubak. (Text-fig. 29, and Plate 47, fig. 2.)

Bubak, *Archiv pro Prirod. Vyzk. Cech*, dil. 15, C. 3, p. 33, 1912.

Uredo olivacea DC., *Fl. Fr.*, vol. 6, p. 78, 1815. *Ustilago olivacea* (DC.) Tul., *Ann. Sci. Nat.*, ser. 3, vol. 7, p. 88, 1847. *U. caricicola* Tracy and Earle, *Bull. Torrey Cl.*, vol. 26, p. 493, 1899. *U. catenata* Ludw., *Zeitschr. Pflanzenkr.*, vol. 3, p. 139, 1893.

Sori in occasional ovaries, at first compact and partially concealed within the perigynium, becoming pulverulent, olive-brown, up to 5 mm. long, intermixed with numerous conspicuous yellowish elaters, which attain a length of 22 mm. but are usually much less, averaging 5–8 mm.

Spores globose to shortly elliptical, frequently irregular, often arranged in chains, 7–14 × 4–7 mmm.; epispore closely and finely verrucose, pallid olive, 0·5–1 mmm. thick.

Hosts: -

Carex virgata Sol. In inflorescences. Herb. Nos. 499, 1249. Pencarrow (Wellington), sea-coast, *E. H. Atkinson!* 10 Feb., 1921.

Carex dipsacea Berggr. In inflorescences. Herb. No. 1250. Tapuwai, Hokianga (Auckland), 12 m., *E. H. Atkinson!* 18 Dec., 1923.

Distribution: World-wide.

Both hosts are endemic, and are widely distributed throughout the lowland areas of both Islands (Cheeseman, 1906, pp. 814-822).

The olive colour of the sori, and especially the straw colour of the elaters, together with the larger and more irregular spores, separate this from the two preceding species. The markings on the epispore are also characteristic, for they are more of the nature of warts, appearing flattened and closely crowded together.

Ustilago catenata Ludw. was based on a specimen of a host supposed to be a species of *Cyperus*, but McAlpine (1910, p. 158) states that he had portion of the type examined by Mr. L. Rodway, Government Botanist, Hobart, who pronounced it to be *Carex pseudo-cyperus* L.

Germination.—In water this commences within a few hours, a fine probasidium being produced. This elongates but does not become septate, and is then detached as a conidium. In the case of the larger spores a second conidium may be produced, depending on the quantity of the protoplasm contained within the spore. In nutrient solution, according to Brefeld (1883), budding occurs to a slight extent. When this process of germination is compared with such a species as *Ustilago Avenae*, in which a definite septate probasidium is produced, it appears rather a stretch of imagination to term the germination product a probasidium; rather should it be considered a conidium, for it behaves in a similar manner, and is about the same size and shape.

3. Cintractia Cornu.

Cornu, *Ann. Sci. Nat.*, ser 4, vol. 15, p. 279, 1883.

Anthracoidea Bref., *Unters. Gesammt. Myk.*, vol. 12, p. 144, 1895.

Sori in the form of a firmly compacted black spore-mass, usually surrounding a central columella of host-tissue, situated in various parts of the host, usually in the inflorescence.

Spores single, globose or more commonly angular, epispore coloured, smooth or verruculose, germination as in *Ustilago* or slightly modified.

Distribution : World-wide.

Of the three species that have been collected in New Zealand, one is endemic, the others indigenous. Eleven species are recorded by McAlpine (1906) for Australia, and thirteen for North America by Clinton (1906).

Members of the genus occur on the families Gramineae, Cyperaceae, and Juncaceae.

The genus is characterized by the (usually) compact sori, central columella of host-tissue, and centripetal manner of spore-formation.

Germination occurs as in *Ustilago*, but in one species, *C. Caricis*, the apical cell of the probasidium becomes longitudinally septate, each cell producing a conidium. On this character Brefeld erected the genus *Anthracoidea*.

Spore-formation has been studied by Cornu (*l.c.*, p. 269). In the position of the future sorus the mycelium penetrates into and becomes aggregated around a central columella of host-tissue ; in this the mycelium persists. On the periphery of this columella the sporiferous hyphae develop ; they soon become gelatinized, when the whole mass appears as a gelatinous cylinder applied to the central columella. These hyphae become septate, and the spores commence their development within the lumen of the cells thus formed. Development proceeds from the periphery of the mass inwards, so that mature spores appear first at the periphery. A section through a sorus shows mature spores on the outside, and increasingly immature spores as the columella is approached, until near this axis the spores are seen to be little more than gelatinous masses. As the spores near maturity the hyaline envelopes surrounding them become absorbed ; the spores become exposed and assume a dark colour, but remain firmly agglutinated together, probably adhering by remnants of the gelatinous hyphae, for when placed in water the sori readily break up. In several species all the sporogenous hyphae do not develop spores, but many remain sterile, and may be seen projecting between rows of the spores.

Key to the Species.

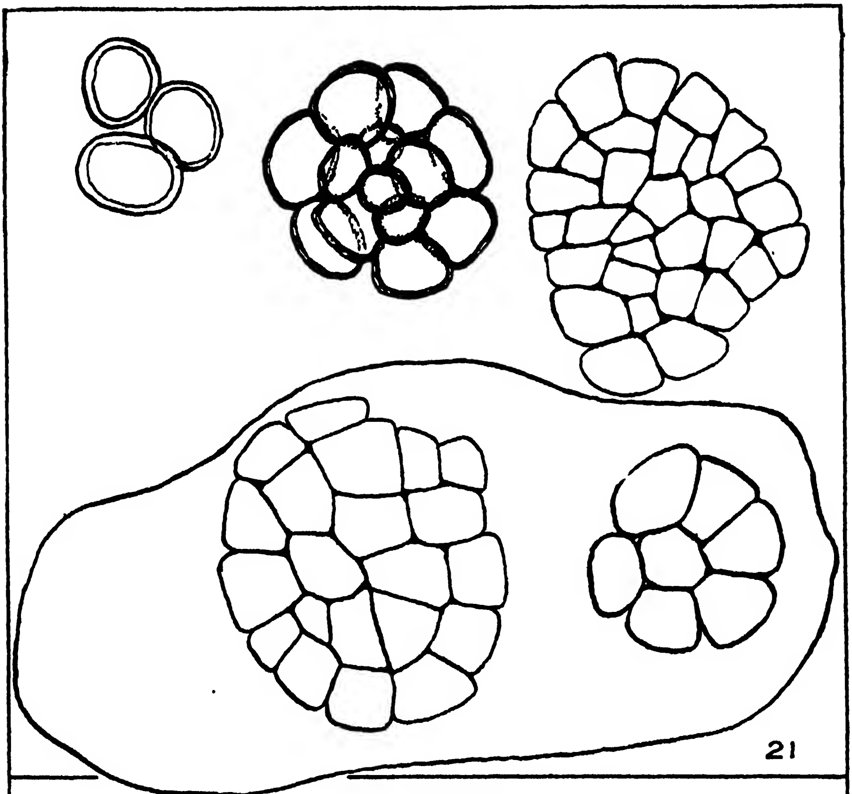
Spores minute, under 6 mmm. long	1. *C. Spinificis.*
Spores large, over 10 mmm.	
On *Carex*	2. *C. Caricis.*
On *Uncinia*	3. *C. sclerotiformis.*

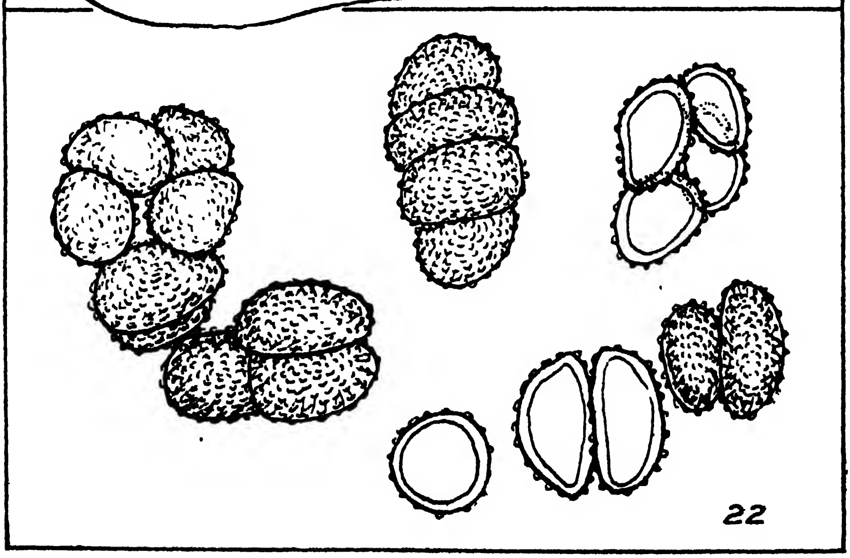
1. Cintractia Spinificis (Ludwig) McAlpine. (Text-fig. 15, and Plate 45, fig. 1.)

McAlp., *Smuts Austr.*, p. 174, 1910.

Ustilago Spinificis Ludw., *Zeitschr. Pflanzenkr.*, vol. 3, p. 138, 1893.

Sori in spikelets, frequently concealed within the glumes, destroying the ovaries and forming in their stead a compact cylindrical olive-black spore-mass, which may attain a length of 7 mm.





TEXT-FIG. 21.—*Sorosporium solidum* (Berk.) McAlp., from *Schoenus Carsei* Cheesem.
TEXT-FIG. 22.—*S. Neillii* G. H. Cunn., from *Scirpus nodosus* Rottb.

× 1,000.

Spores globose to shortly elliptical, 3–5 × 2·3 mmm.; epispore very delicately but distinctly verruculose, pallid olive, with a lighter-coloured zone on one side, 0·5 mmm. thick.

Host: *Spinifex hirsutus* Lab. In male and female spikelets. Herb. Nos. 309, 1259. Pencarrow (Wellington), sea-coast, *E. H. Atkinson!* 10 Feb., 1921.

Distribution: Australia.

The host is indigenous and widely distributed along the coast: it occurs also in Australia and New Caledonia (Cheeseman, 1906, p. 850).

Osborn (1922) has recorded the pathological changes this species effects in the host. The inflorescences, both male and female, become considerably modified, the anthers become sterile, and the filaments do not elongate, and the various organs are modified in number, structure, and position.

Germination, according to McAlpine (*l.c.*, p. 174), does not occur in water, but takes place readily in nutrient solution. A four-celled probasidium is produced, and on this are borne the conidia. These multiply by budding, but before the solution is exhausted the conidia may produce hyphae which, if they reach the air, form abundant aerial conidia.

I have failed to germinate the spores either in water or nutrient solution, but the material was probably too old, for it has been kept in the herbarium for twenty-one months.

2. Cintractia Caricis (Persoon) Magnus. (Text-fig. 14, and Plate 44, fig. 2.)

Magn., *Abh. Bot. Ver. Prov. Brand.*, vol. 37, p. 79, 1896.

Uredo Caricis Pers., *Syn. Fung.*, p. 225, 1801. *Ustilago Caricis* Ung., *Einfl. Bodens*, p. 211, 1836. *U. urceolorum* Tul., *Ann. Sci. Nat.*, ser. 3, vol. 7, p. 86, 1847. *U. Scirpi* Kuehn. *Hedw.*, vol. 12, p. 150, 1873. *Anthracoidea Caricis* Bref., *Unters. Gesammt. Myk.*, vol. 12, p. 144, 1895.

Sori in occasional ovaries, at first partially concealed within the perigynium, becoming exposed when subglobose or elliptical, 3–7 mm. long, at first covered by an evanescent white membrane of semi-gelatinized hyphae which later falls away, exposing the black, firmly agglutinated spore-mass.

Spores irregular, subglobose or more frequently polygonal, 16–27 × 9–15 mmm.; epispore minutely and densely verruculose, frequently obscurely pitted, sepia-coloured, 1·5–2 mmm. thick

Hosts:—

Carex Gaudichaudiana Kunth. In inflorescences. Herb. No. 1261. Lake Wakatipu (Otago), 340 m., *L. Cockayne!* 1909.

Carex subdola Boott. Herb. No. 1263. Lake Wakatipu (Otago), *L. Cockayne!* 1909.

Carex ternaria Forst. f. Herb. Nos. 295, 1260, 1262, 1264. Peel Forest (Canterbury), 120 m., *H. H. Allan!* 5 April, 1919. Tasman (Nelson), 10 m., *G. H. C.* 4 Feb., 1920. Seatoun (Wellington), sea-shore, *E. H. Atkinson! G. H. C.* 25 Jan., 1921. *J. C. Neill! G. H. C.* 6 Dec., 1923.

Carex sp. Herb. No. 45. Southern Alps, Canterbury, *T. Kirk!* 1883.

Distribution: World-wide.

Of the hosts, two of the named species are endemic; the third, *C. Gaudichaudiana*, is indigenous, occurring also in Australia (Cheeseman, 1906, pp. 818–20).

In certain specimens the sori project beyond the perigynium for several millimetres, giving to infected plants a very conspicuous appearance. Sori may be confined to occasional ovaries, or every ovary in the inflorescence may be infected.

Germination. In water a probasidium is produced which becomes septate in the normal manner save that in addition the terminal cell becomes longitudinally septate. From each of the two cells thus formed a conidium is produced, as well as numerous lateral conidia. The conidia produce infection hyphae in the normal manner. It is claimed that germination does not occur until the spores are twelve months old.

3. **Cintractia sclerotiformis** (Cooke and Massee) n. comb. (Text-fig. 13, and Plate 47, fig. 1.)

Ustilago sclerotiformis Cke. et Mass., *Grev.*, vol. 17, p. 8, 1888.

Sori in occasional ovaries, sometimes in all, at first partially concealed within the perigynium, becoming exposed when compact, black, elliptical, up to 6 mm. long.

Spores subglobose to elliptical, commonly polygonal, 16–22 × 11–18 mmm.; epispore closely and minutely verruculose, dark brown, 1·5 mmm. thick.

Hosts :—

Uncinia caespitosa Boott. In inflorescences. Taheraiti, *T. Kirk.* (Type in Herb. Kew.)

Uncinia leptostachya Raoul. Herb. No. 20. Peel Forest (Canterbury), 120 m., *H. H. Allan !* Feb., 1920.

Uncinia riparia R. Br. Herb. No. 1257. Peel Forest (Canterbury), 120 m., *H. H. Allan !* 5 April, 1919. Mount Peel (Canterbury), 700 m., *H. H. Allan !* 6 Mar., 1921. Botanical Gardens, Wellington, 80 m., *E. H. Atkinson ! G. H. C.* 19 Jan., 1921. *J. C. Neill ! G. H. C.* 4 Dec., 1923.

Distribution : New Zealand.

The first two hosts are endemic, the third occurs also in Australia; all are widely distributed throughout New Zealand (Cheeseman, 1906, pp. 801 3).

This is a true *Cintractia*, for a transverse section shows that it possesses all the characters of this genus. The species is closely related to the preceding, but is separated by the comparatively broader and smaller spores, more conspicuous markings, and thinner nature of the epispore.

I have been unable to germinate the spores.

4. SPHACELOTHECA de Bary.

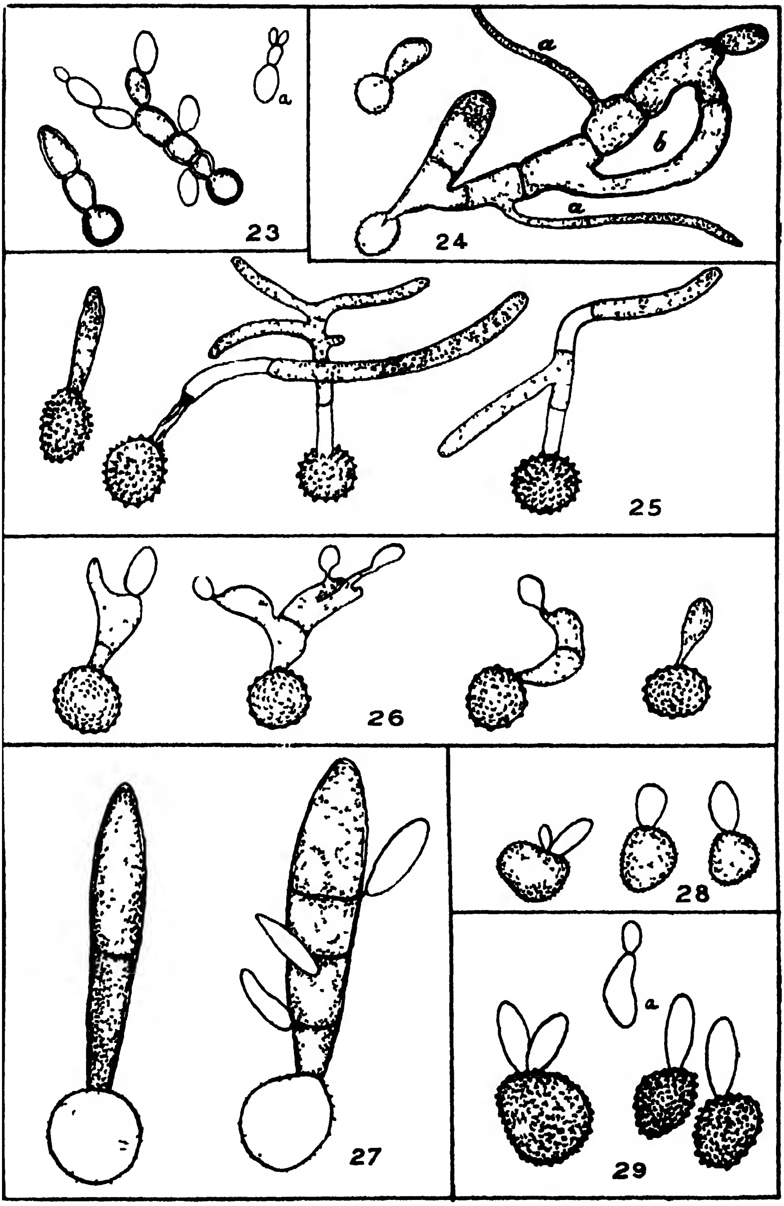
De By., *Verg. Morph. Biol. Pilze*, p. 187, 1884.

Endothlaspis Sor., *Rev. Myc.*, vol. 12, p. 4, 1890.

Sori in the form of a pulverulent spore-mass, surrounding a central columella of host and fungous tissues, enclosed within a more or less permanent false membrane of fungous tissue, becoming exposed either by apical or irregular rupture of this membrane.

Spores single, epispore coloured, smooth or variously sculptured; germination as in *Ustilago*.

Distribution : World-wide.



SPORES GERMINATING IN WATER: SHOWING THE DIFFERENT METHODS.

TEXT-FIG. 23.—*Ustilago levis* Magn.: *a*, conidium producing secondary conidia by budding.

TEXT-FIG. 24. *U. Tritici* Jens.: *a*, infection hyphae produced from cells of the probasidium; *b*, conjugating hyphae.

TEXT-FIG. 25.—*U. striaeformis* (Westnd.) Niessl (modified from Osner).

TEXT-FIG. 26.—*U. bromivora* (Tul.) F. v. Waldh. Two-celled probasidia producing conidia.

TEXT-FIG. 27.—*U. Readeri* Syd.

TEXT-FIG. 28.—*Elateromyces niger* G. H. Cunn. Spores producing conidia, probasidia being absent.

TEXT-FIG. 29.—*E. olivaceus* (DC.) Bubak. Spores producing conidia.

All × 1,000.

Only a single indigenous species has as yet been collected in New Zealand. In North America Clinton (1906) records sixteen species, all, with one exception, confined to the Gramineae; the exception occurs on the Polygonaceae.

The method of development, structure, and nature of the columella and enclosing membrane—structures on which the genus is separated from *Ustilago*—are dealt with under the species.

Spore-formation.—This is similar to *Ustilago* save that the process is confined to a definite region of the sporiferous hyphae; the columella and receptacle, although formed from potentially sporogenous tissue, remaining sterile.

The genus is separated from *Ustilago* on account of the presence of a definite false membrane of fungous tissue surrounding the sorus. This membrane is somewhat urn-shaped, and encloses a cavity in which are situated the pulverulent mass of spores arranged around a central columella of combined host and fungous tissue.

1. **Sphacelotheca Hydropiperis** (Schumacher) de Bary. (Text-fig. 10.)
Polygonaceae.

> *Uredo Hydropiperis* Schum., *Enum. Pl. Saell.*, vol. 2, p. 234, 1803. *Ustilago Candollei* Tul., *Ann. Sci. Nat.*, ser. 3, vol. 7, p. 93, 1847. *U. hydropiperis* Schroet., *Beitr. Biol. Pfl.*, vol. 2, p. 355, 1877.

Sori in the ovaries, up to 5 mm. long, consisting of an outer urn-shaped receptacle composed of fungous cells, opening at the apex by a reflexed margin, enclosing the dark-purple spore-mass, which in turn surrounds the more or less evident columella.

Spores subglobose to shortly elliptical, 10–17 × 11–13 mmm.; epispore minutely and closely verruculose, dark purple, 1 mmm. thick.

Hosts:—

Polygonum serrulatum Lag. (= *P. prostratum* A. Rich.). In inflorescences. North Island, *W. Colenso.*

Polygonum sp. Herb. No. 1272. Kaitaia, North Auckland, *E. H. Atkinson!* 16 Dec., 1923.

Distribution: World-wide.

The former host is indigenous and widespread; it occurs also in Australia, Europe, Asia, &c. (Cheeseman, 1906, p. 590).

The species was first recorded by Berkeley (1855) for New Zealand from specimens collected by Colenso; he determined the species as *Ustilago Candollei* var. *a* Tul.

Infection occurs in the seedling stage, according to De Bary (1887), the hyphae growing with the growing-point until the ovaries are formed. When the ovule is formed the hyphae pass into it through the funiculus, completely replacing it and forming in its stead a compact hyphal mass. This mass later becomes differentiated into an outer sterile layer enclosing a central columella; between these two structures the spores are formed. The whole of this tissue is at first enclosed within the ovary-wall, but, owing to continuous development of these structures by formation of fresh hyphae at their base, the spore-receptacle with its enclosed structures soon outgrows and ruptures the ovary, which may sometimes fall away.

Germination is effected by the production of a probasidium, which produces lateral conidia, as does *Ustilago Avenae.*

5. TILLETIA Tulasne.

Tul., *Ann. Sci. Nat.*, ser. 3, vol. 7, p. 112, 1847.

Sori in the form of a black spore-mass in various parts of the host, usually in the ovaries, frequently fetid, pulverulent or not.

Spores single, epispore coloured, smooth or variously sculptured; germination by means of a short probasidium producing a terminal whorl of elongate conidia, which often give rise to secondary conidia on germination.

Distribution: World-wide.

The four species that have been collected in New Zealand are all introduced. McAlpine (1906) records five species for Australia; Clinton (1906) twenty-two for North America.

The genus is separated from *Ustilago* mainly on account of the methods of germination and spore-formation. When these characters are unknown the species may be placed in either genus, but the large-spored forms are usually considered to belong to *Tilletia*.

Spore-formation.—According to Fischer von Waldheim (1869), prior to spore-formation the sporogenous hyphae produce in succession numerous lateral pyriform branches. These increase in diameter at their apices, finally appearing as globular bodies surrounded by a gelatinous membrane and attached to the main hyphae by slender stalks. Within the gelatinous walls the spores develop, and as they approach maturity the gelatinous membrane gradually becomes absorbed. Thus in this genus spore-formation is acrogenous, differing in this respect from *Ustilago*, in which the method of spore-formation is intercalary.

The genus is confined to the Gramineae, although it has been recorded (doubtfully) as occurring on *Sphagnum* (Musci).

KEY TO SPECIES.

Spores smooth	2. *T. levis*.
Spores reticulate.	
On *Agrostis*	1. *T. decipiens*.
On *Holcus*	4. *T. Holci*.
On *Triticum*	3. *T. Tritici*.

1. Tilletia decipiens (Persoon) Koernicke. (Text-fig. 17.) Gramineae.

Koern., in Wint. *Die Pilze*, vol. 1, p. 110, 1884.

Uredo segetum var. *decipiens* Pers., *Syn. Fung.*, p. 225, 1801. *Tilletia sphaerococca* F. v. Waldh., *Bull. Soc. Nat. Mosc.*, vol. 1, p. 14, 1867.

Sori in ovaries, concealed within the glumes, black, compact, fetid.

Spores globose or subglobose, 24–30 × 22–26 mmm.; epispore covered with a network of raised reticulations 2·5 mmm. high, surrounding polygonal depressions 3–5 mmm. wide, pallid brown.

Host: *Agrostis vulgaris* With. In inflorescences. Herb. No. 176. Wyndham (Southland) *E. Bruce Levy!* 1 Mar., 1920. Khandallah (Wellington), 200 m., *E. Bruce Levy!* 5 April, 1922. Tapanui (Otago), *J. C. Neill! G. H. C.* 2 Feb., 1924.

Distribution: Europe.

The host is an introduced species, abundant throughout. The fungus exerts a stunting effect on the host; its presence may be noted on this account and also because infected plants are of a more pallid colour than the normal. Fresh specimens are slightly fetid when crushed.

The mycelium perennates in the perennial parts of the host.

Germination.—In nutrient solution a probasidium bearing a terminal whorl of fusiform septate conidia is produced. The conidia may produce sickle-shaped secondary conidia whilst still attached to the probasidium.

2. Tilletia levis Kuehn. (Text-figs. 19, 30.)

Kuehn, *Hedw.*, vol. 12, p. 152, 1873.

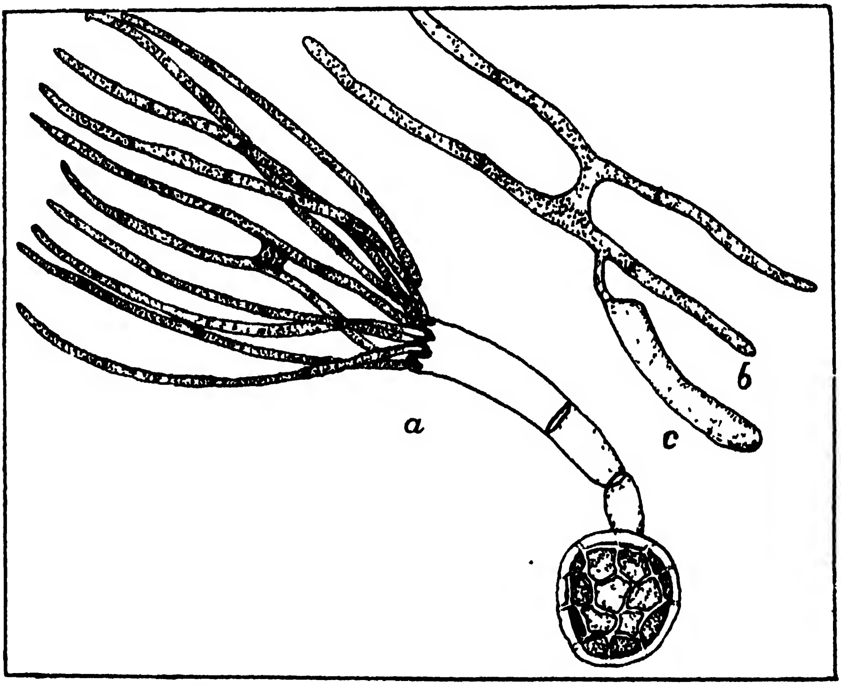
Ustilago foetens Berk. et Curt., *Grev.*, vol. 3, p. 59, 1874. *Tilletia foetens* (B. & C.) Trel., *Parasit. Fung. Wis.*, p. 35, 1884.

Sori in ovaries, concealed within the glumes, ovate or elliptical, 5–8 mm. long, dark brown, fetid.

Spores globose to shortly elliptical, 17–25 × 15–17 mmm.; epispore smooth, pallid brown, 1·5–2 mmm. thick.

Host: *Triticum vulgare* Vill. In inflorescences. Herb. Nos. 401, 1266. Ashburton (Canterbury), 30 m., *H. H. Allan!* 21 March, 1921. Lincoln (Canterbury), 80 m., *F. E. Ward!* 27 Jan., 1922.

Distribution: World-wide.



TEXT-FIG. 30.—*Tilletia levis* Kuehn. *a*, septate probasidium with a terminal whorl of conidia; *b*, conjugating conidia, producing secondary conidia, *c*.

This, together with the following species, is known as "stinking-smut" of wheat, on account of the fetid smell the spore-mass emits when crushed.

The stinking-smuts are the two most important smuts attacking this host, for not only do they destroy the inflorescences, but their presence, even in small quantities, renders the grain unfit for milling, partly on account of the musty smell such grain possesses, partly because the flour is supposed to have a toxic effect when consumed. It is further claimed that if such grain be fed to poultry disastrous results may follow. For example, McAlpine (1910, p. 81) records the effect upon the egg-laying propensities of 650 fowls fed with smutted wheat: the egg-yield dropped from a daily average of 100 to 16. Other authors record detrimental effects to stock, such as staggering, inflammation, and even occasional abortion.

On the other hand, some workers consider that these reports are much exaggerated, and record experiments in which no detrimental results followed. Baudys (1921) experimented with animals, and also upon himself, without any ill effects. Poultry, mice, and rabbits were fed on smutted grain (*T. Tritici*) and actually increased in weight; he himself was not affected in any way.

When threshed the infected grains, which are hard and compact, may pass through the machine and be distributed in this manner, when they are usually termed "smut-balls." It has been shown by von Liebenberg (1879) that the spores may retain their viability up to eight years, if kept in a dry place.

Infection occurs in the seedling stage, as in *Ustilago Avenae*. Germination has been worked out and figured by numerous authors, being first recorded by Berkeley (1847).

In water a probasidium is produced, and on the end of this is borne a whorl of slender sickle-shaped conidia. The conidia may in turn produce either stout allantoid secondary conidia, or else directly produce infection hyphae.

This and the following species are readily controlled by steeping the grain prior to sowing in some suitable fungicide. For this purpose copper-sulphate solution, formalin, and, as a dry treatment, copper-carbonate, are usually recommended.

3. Tilletia Tritici Winter. (Text-fig. 18.)

Wint., in Rabh. *Krypt. Fl.*, vol. 1. p. 110, 1881.

Uredo Caries DC., *Fl. Fr.*, vol. 6, p. 78, 1815. *Tilletia Caries* Tul., *Ann. Sci. Nat.*, ser. 3, vol. 7, p. 113, 1847. *T. Secalis* (Cda.) Kuehn, in F. v. Waldh., *Apercu Syst. Ust.*, p. 50, 1877.

Sori in ovaries, concealed within the glumes, shortly elliptical, 4–6 mm. long, dark brown, fetid.

Spores globose or subglobose, 16-24 mmm. diam.; epispore with a network of raised reticulations about 1 mmm. high, surrounding polygonal depressions 2–4 mmm. wide, pallid brown.

Host: *Triticum vulgare* Vill. In inflorescences. Herb. No. 599. Lincoln (Canterbury), 80 m., *F. E. Ward!* 27 Jan., 1922.

Distribution: World-wide.

This is separated from the preceding species on account of the reticulate spores. Both species occur on the same host, frequently in the same spike.

Gaines and Stevenson (1923) give as a synonym *Tilletia Secalis* Kuehn., for they have shown the form on rye to be identical with the above, differing only in that it is found on a different host.

Potter and Coons (1918) claim that this species may be separated from the preceding in the field on account of the following differences:—

Tilletia Tritici.	*Tilletia levis.*
Considerably stunts the host.	Has little stunting effect.
Causes infected grains to become much inflated, and consequently shorter in length.	Has little effect upon the shape of the grain, merely causing it to shrivel slightly.
Spore mass more powdery, friable, or even granular.	Spore-mass inclined to be unctuous.

Germination and method of infection are similar to the preceding.

4. Tilletia Holci (Westendorp) Rostrup. (Text-fig. 16.)

Rostr., *Ust. Daniae*, p. 156, 1890.

Polycystis Holci Westnd., *Bull. Acad. Belg.*, ser. 2, vol. 11, p. 660, 1860. *Tilletia Rauwenhoffii* F. v. Waldh., *Apercu Syst. Ust.*, p. 50, 1877.

Sori in ovaries, partially concealed within the glumes, elliptical, 1–2 mm. long, compact, black, slightly fetid.

Spores globose or subglobose, 22–32 × 24–28 mmm.; epispore covered with a network of raised reticulations 3–4·5 mmm. high, surrounding polygonal depressions 4–7 mmm. wide, chestnut-brown.

Host: *Holcus lanatus* L. In inflorescences. Herb. No. 500. Ettrick (Otago), 300 m., *R. B. Tennent!* 10 Feb., 1921.

Distribution: Europe; North America.

I have a collection of *Holcus lanatus* L. with this species in the ovaries and *Ustilago striaeformis* in the leaves.

The three species possessing reticulate spores may readily be separated if the following differences are noted:—

Spores under 25 mmm.	*T. Tritici.*
Spores over 25 mmm.	
Reticulations 2–2·5 mmm. high	*T. decipiens.*
Reticulations 3–4·5 mmm. high	*T. Holci.*

Furthermore, the reticulations of *T. Holci* are coarse, and separated by large polygonal interspaces; those of *T. decipiens* are closely compacted, being separated by much smaller areas; whilst those of *T. Tritici* are intermediate in size.

I have been unable to germinate the spores of *T. Holci.*

6. SOROSPORIUM Rudolphi.

Rud., *Linnaea*, vol. 4, p. 116, 1829.

Sori in the form of dark-coloured pulverulent spore-masses in various parts of the host, chiefly in the inflorescences, formed of numerous spore-balls, consisting of few or many spores, at first somewhat loosely united, but at maturity completely separating; sterile cells absent.

Spores coloured some shade of brown, globose to angular, smooth or verruculose; germination similar to that of *Ustilago.*

Distribution: World-wide.

New Zealand species two—one endemic, the other indigenous; both are confined to the Cyperaceae. Members of the genus have elsewhere been recorded on the following families: Gramineae, Cyperaceae, Juncaceae, Portulaceae, and Caryophyllaceae. McAlpine (1910) records thirteen species for Australia.

The genus is characterized by the rather temporary nature of the spore-balls, for these generally break up at maturity, when species cannot be distinguished from *Ustilago.* In one or two species the balls remain somewhat firmly united, when they are liable to be confused with the allied genera *Thecaphora* and *Tolyposporium.* The former may be separated by the pallid colour of the spore-balls, and the fact that the spores are variously marked on their free, but smooth on their united surfaces (seen when the spores are separated), the latter by the individual spores being firmly united in the ball by ridged folds of their epispores.

Spore-formation has been investigated by Fischer von Waldheim (1869) in the type species, *S. Saponariae* Rud. The mycelium in the infected region

changes somewhat rapidly to sporiferous hyphae, which soon become gelatinized. At various points several of these hyphae become twisted into small masses, become gelatinized, and lose their outlines. They then become enclosed by other hyphae from the adjoining mycelium. These hyphae also become gelatinized, and in consequence their outlines are indistinct. In the centre of these masses spore-differentiation commences: the spores are at first clear, but quickly change colour, becoming brown. At this stage they are few in number and immature. They then divide until the number of the mature ball is arrived at, the gelatinous outer zone of hyphae gradually disappearing until at maturity practically no trace remains.

KEY TO SPECIES.

Spore-balls of 2–6 spores	1. *S. Neillii.*
Spore-balls of 15–50 spores	2. *S. solidum.*

1. Sorosporium Neillii n. sp. (Text-fig. 22, and Plate 46, fig. 1.)
Cyperaceae.

Sori in occasional ovaries, frequently in all, at first enclosed within the perigynium, becoming exposed when black, compact, globose or elliptical, 3–4 mm. long. Spore-balls of 2–6 spores, irregularly elliptical, dark chestnut-brown, up to 50 mmm. long, readily breaking up at maturity.

Spores irregular, angular, subglobose or elliptical, frequently flattened on one side, 12–20 × 9–15 mmm.; epispore coarsely and densely verrucose, chestnut-brown, 1·5–2 mmm. thick.

Host: *Scirpus nodosus* Rottb. In inflorescences. Herb. Nos. 1279, 1285. Bluff (Southland), seashore, *W. D. Reid!* 26 May, 1922. Seatoun (Wellington), seashore, *J. C. Neill! G. H. C.* 6 Dec., 1923.

Distribution: Australia.

The host is indigenous and abundant throughout: it occurs also in Australia, South Africa, and South America (Cheeseman, 1906, p. 776).

Germination.—In water germination commenced in three days; a short and slender probasidium is produced, and on this, both laterally and terminally, conidia are produced. In certain specimens the terminal conidium is formed before the probasidium becomes septate, but as a rule septation precedes the production of conidia.

This species differs from *S. piluliformis* (Berk.) McAlp., on *Scirpus prolifer* Rottb., in that the spore-balls are less than half the size, are lighter in colour, and break up readily; the spores are larger, and possess more verrucose, not tuberculate, epispores.

[*Latin diagnosis.*]

Sorosporium Neillii.

Soris ad ovaria pauca destruentibus; atris, compactis, globosis vel ellipticis, 3–4 mm. longis. Spororum pilis sporis 2–6; inaequaliter ellipticis, atro-castaneis, ad 50 mmm. longis; facile disruptis maturitate.

Sporis inaequaliter angulatis, subglobosis vel ellipticis, 12–20 × 9–15 mmm.; episporio crasse denseque verruculoso, castaneo, 1·5–2 mmm. crasso.

Hab.: In ovariis *Scirpi nodosi* Rottb. Bluff (Southland, N.Z.), *W. D. Reid!* Seatoun (Wellington, N.Z.), *J. C. Neill!*

2. Sorosporium solidum (Berkeley) McAlpine. (Text-fig. 21.)

McAlp., *Smuts Austr.*, p. 183, 1910.

Ustilago solida Berk., *Fl. Tas.*, vol. 2, p. 270, 1860. *Urocystis solida* F. v. Waldh., *Apercu Syst. Ust.*, p. 38, 1877.

Sori in occasional spikelets, partly enclosed within the glumes, at first compact, becoming pulverulent, black, elliptical, 3–4 mm. long. Spore-balls subglobose to elliptical, often irregular, composed of from 15 to 50 or more similarly coloured spores somewhat firmly united, attaining a size of 115×50 mmm., although commonly much less, averaging about 50 mmm.

Spores subglobose or somewhat angular, 12-18×10–15 mmm.; epispore smooth, dark chestnut-brown, 1 mmm. thick.

Host: *Schoenus Carsei* Cheesem. In spikelets. Herb. No. 423. Auckland, *T. Patterson!* Oct., 1921.

Distribution: Australia.

The host is confined to the swamps of the Auckland and Taranaki Provinces (Cheeseman, 1906, p. 781).

The New Zealand form differs from the description given by McAlpine in that the sori are (when mature) pulverulent, the spore-balls larger, and the spores slightly smaller (McAlp., 20-24 mmm. long.).

I have been unable to germinate the spores.

7. UROCYSTIS Rabenhorst.

Rabenh., Klotsch, in *Herb. Viv. Myc.*, ed. 2, No. 393, 1856.

Polycystis Lev., *Ann. Sci. Nat.*, ser. 3, vol. 5, p. 269, 1846.

Sori in the form of dark-coloured pulverulent masses of spore-balls, usually in the leaves and stems of the host, occasionally in the inflorescences. Spore-balls compact, permanent, of one or many fertile cells, enclosed within an envelope of few or many tinted sterile cells.

Spores dark-coloured, irregular in shape; epispore smooth or variously sculptured; germination by means of a short probasidium, producing terminally one or a whorl of elliptical conidia, which on germination produce either secondary conidia or infection hyphae.

Distribution: World-wide.

The following species is the sole representative of the genus that has been as yet collected in New Zealand.

Members of the genus have been found on the following host families: Gramineae, Cyperaceae, Juncaceae, Liliaceae, Amaryllidaceae, Ranunculaceae, Rosaceae, and Violaceae.

The genus is characterized by the permanent spore-balls, which consist of one or several dark-coloured spores surrounded wholly or in part by an envelope of sterile cells. The phyllogenous habit, and tendency to gall-formation, are also characteristic.

Spore-formation has been worked out by De Bary (1887). His work has since been supplemented by numerous other workers. The sporiferous hyphae branch, become gelatinized, somewhat swollen, then twined into an indistinguishable semi-gelatinous mass. In the central portions of this mass the spores become differentiated; the outer layer of the mass consists of slender branches derived from the gelatinous mass of hyphae. These become divided by transverse septa into numerous short cells; several persist as the sterile envelope so characteristic of the genus, the remainder become absorbed as the spores mature.

1. **Urocystis Anemones** Winter. (Text-fig. 20, and Plate 45, fig. 2.) Ranunculaceae.

Wint. in Rabh. *Krypt. Fl.*, vol. 1, p. 123, 1881.

Sori in leaves (when chiefly epiphyllous), petioles, and stems, forming irregular swellings, at first covered by the epidermis, becoming exposed when appearing as a pulverulent black mass. Spore-balls irregular, from 15 to 30 mmm. in length, composed of from one to five spores, partially surrounded by more numerous and smaller sterile cells.

Spores subglobose to polygonal, 10 15 × 8–14 mmm.; epispore smooth, or sometimes delicately verruculose, dark brown, 1 mmm. thick; sterile cells subglobose to polygonal, pallid brown, smooth, often reduced or wanting.

Host: *Ranunculus insignis* Hook. f. On leaves and petioles. Herb. No. 503. Mount Dennan, Tararua Mountains (Wellington), 1,500 m., *E. H. Atkinson!* 7 Jan., 1922.

Distribution: World-wide.

The host is endemic, and confined to the mountain-ranges of both Islands (Cheeseman, 1906, p. 10).

Infection experiments were carried out by Plowright (1889, p. 94). He applied conidia to the foliage of *Ranunculus repens*, and two months later, in the vicinity of the points of inoculation, he observed signs of the formation of the spore-beds. He found the mycelium to be localized, infection occurring wherever the infection hyphae penetrated.

Germination has been observed and figured by numerous workers. In water, after forty-eight hours, a probasidium is produced, on the apex of which a whorl of three or four conidia is formed.

Brefeld (1895) found that the spores would germinate only after six months' rest in damp earth; but Kniep (1921) found that forms from different hosts differed, in that some required this period of rest, whilst others germinated as soon as they were mature. He considered the species to be in reality an aggregate one, thus explaining the differences in germination as recorded by various workers.

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COMBINED HOST AND FUNGUS INDEX.

All synonyms are in italics. Page numbers of synonyms and of incidental references are in ordinary type; those under which are to be found descriptions of species, genera, or families, or hosts of these species, are in italics. An asterisk preceding a page number indicates that an illustration of the species in question will be found on that page.

This index gives only those synonyms that have been used in recent literature, or are some guide to the species in question.

Descriptions of New Native Flowering-plants.

By D. Petrie, M.A., Ph.D., F.N.Z.Inst.

[*Read before the Auckland Institute, 2[illegible]th November, 1923; received by Editor, 31st December, 1923; issued separately, 30th July, 1924.*]

1. Senecio Spedeni sp. nov.

Species *S. Monroi* Hk. f. similis; differt habitu humili, foliis angustioribus, sessilibus, integris, obtusis v. subacutis; acheniis tenuibus, apice ± dilatatis, glaberrimis.

A compactly-branched densely leafy depressed shrub, about 18 in. (45 cm.) high and some 24 in. (60 cm.) across. Main branches from base, the lower spreading close to ground, the others suberect and ending in corymbosely-arranged one-headed branchlets. Leaves closely placed, more or less imbricating, narrow obovate-oblong, ⅝ in. (15 mm.) long, ¼ in. (6 mm.) broad, obtuse or subacute, coriaceous, entire, strongly viscid, gradually narrowed to sessile base, above glabrous and closely punctulate, below clothed with closely appressed whitish tomentum, midrib and slightly diverging veins obscure. Flowering branchlets about 8, closely placed in corymbose fashion near their tips, ± 2 in. (5 cm.) long, slender, smoothly tomentose, each bearing a single flower-head; bracts rather distant, like the leaves but narrower. Heads ± turbinate, ± ⅜ in. (9 mm.) wide; involucral bracts 10–12, linear, acute, tomentose; ray florets 8–10, yellow; achenes linear, slender, grooved, glabrous, somewhat dilated at the tips.

Hab. Richardson Range, Lake County, near Minor Peak (on the track to Lake Luna), *circa* 4,000 ft. J. Speden.

Mr. Speden has had this plant in cultivation for several years. I have seen cultivated specimens only. Its dwarf compact habit, shining foliage, and abundant flowers make it a charming garden-plant.

2. Senecio Matthewsii sp. nov.

Species *S. lapidoso* Cheesem. affinis; differt habitu altiore, ramis confertis numerosis tenuibus, suberectis v. ascendentibus; foliis multo minoribus, tenuioribus, integris, subacutis, ± longi-petiolatis, a latere superiore haud v. vix tomentosis; bracteis majoribus; acheniis brevibus, linearibus, glaberrimis, ± sulcatis.

A low much-branched shrub, 1½ ft. (4·5 dcm.) high or more. Stems short, giving off from base numerous suberect or ascending much-subdivided branches, leafy chiefly at and near tips, forming compact rounded head; bark loose, thin, brownish; ultimate twigs clothed more or less with silky pubescence. Leaves closely placed, spathulate or subspathulate (petiolar part as long as or shorter than blades), ⅝–⅞ in. (15–21 mm.) long and about half as broad, thin, subacute, entire, in age almost glabrous above (± tomentose when young), below closely clothed with appressed whitish subtomentose pubescence, veins obscure, midrib evident on both surfaces. Flowering branchlets several, closely placed, slender, 2–3 in. (5–7·5 cm.) long; bracts rather distant, becoming shorter and narrower upwards. Heads solitary, terminal, turbinate, about ¼ in. (6 mm.) across; involucral scales linear-oblong, acute, tomentose; ray florets 12–15, oblong, obtuse, more or less eroded at tips, conspicuously nerved. Achenes short linear-oblong, grooved, glabrous, narrowed at the base.

Hab.—Slopes of Mount Diana, Lake County, Otago, in damp rather open stations at the edge of forest: W. A. Thomson!

Mr. Thomson has sent me all the specimens examined. These he grew in his garden at Half-way Bush, Dunedin. He has also supplied a photograph of the wild plant *in situ*. The species is named in honour of Henry J. Matthews whose investigations shed so much light on the flora of western Otago

3. **Senecio remotifolius** sp. nov.

Species *S. elaeagnifolio* Hk. f. affinis; differt habitu late patente robusto, ramis elongatis, foliis latioribus ac tenuioribus, petiolis longis gracilibus, inflorescentia laterali laxa.

A shrub 4–6 ft. high or more, with rather few widely-spreading more or less subdivided branches. Leaves broadly elliptic, 4–5 in. long exclusive of the petioles, 2½–3 in. wide, subacute, firm but scarcely coriaceous, margins obscurely sinuate in upper half, midrib and veins conspicuous on both surfaces, dull green above with scattered patches of white tomentum chiefly along midrib and veins, below clothed with pale-yellow or greyish-yellow appressed tomentum; petioles about as long as blades, grooved above, clothed with greyish tomentum. Inflorescence axillary towards ends of branches, subpaniculate, 5–6 in. long; rhachis zigzag, giving off below several alternate short more or less divaricating few-flowered branches subtended by small foliaceous bracts, upper portion linear, simple, the whole inflorescence clothed with greyish-white tomentum. Heads on short pedicels, discoid, ¼ in. in diameter; involucral bracts about 8, linear, tomentose. Florets about 12, limb of corolla narrow funnel-shaped, rather deeply 5-toothed, segments revolute. Achene linear, shortly pilose.

Hab—North Island. Open rocky places near mouth of Mokau River; not common: W. A. Thomson!

The only specimen seen came from a plant grown in Mr. Thomson's garden at Half-way Bush, Dunedin. He has had it in cultivation for several years.

4. **Dracophyllum Adamsii** sp. nov.

Frutex conferte ramosus, 10 dcm. (40 in.) altus v. ultra: ramis tenuibus, apices versus multo divisis, ramulos pertenues laterales plerumque paucifoliatos inflorescentiam brevem terminalem gerentes edentibus. Foliis tenuibus, conferte imbricatis, complanatis v. ± concavis, lineari-acuminatis, sensim ad apices longe acuminatos subpungentes angustatis; laminis ± 7·5 cm. (3 in.) longis, basi 2–3 mm. latis, plane v. vix auriculatis; basi vaginante expanso; racemis spiciformibus, haud pedunculatis, angustis, ± 2½ cm. (1 in.) longis, paucifloris; floribus (ad 10) parvis, sessilibus, arcte dispositis, ± 5 mm. longis; sepalis ovato-lanceolatis, acutis, a marginibus ciliatis; corollae tubo angusto, calyce ⅓ longiore, lobis ovatis subacutis patentibus v. ± reflexis; staminibus corollae tubum aequantibus; capsula matura calyce ⅓ breviore.

A much-branched bushy shrub, 3 ft. high or more. Main branches rather slender, much subdivided above; bark greyish-brown; branchlets short, very slender, spreading or ascending, most closely ringed by scars of fallen leaves, leafy at tips; flowering twigs 4 in long, generally bearing few leaves; terminal shoots densely clothed for most of their length with larger and broader leaves. Leaves closely imbricating, ascending or spreading, 3 in. long, 2–3 mm. wide at base, narrow linear-acuminate, tapering

uniformly to acicular subpungent tips, thin, glabrous, finely striate, flattened or slightly concave above, edges very delicately serrate at and near tips: sheathing bases twice as wide as basal part of blades, somewhat ciliate at edges, narrowed upwards or more or less auricled. Inflorescence a spike-like raceme terminating lateral branchlets, not peduncled, ± 1 in. long; flowers 10 or fewer, sessile, ± 5 mm. long; bracts several, ovate from broad base, shortly mucronate, strongly ciliate along edges; sepals one-third shorter than corolla, ovate-lanceolate, acute, ciliate at edges; corolla-tube rather narrow, lobes ovate subacute spreading or more or less reflexed; stamens as long as corolla-tube; mature capsules one-third shorter than sepals.

Hab.—Roadside near mouth of Awatere River, East Cape district: James Adams and D. P. Edge of forest near Peria (Mongonui): H. Carse! Various stations in North Cape district: T. F. Cheeseman!

The species is named in honour of James Adams, whose investigation of the flora of the Coromandel Peninsula is a fine piece of work, and who was my companion on a visit of some length to Mount Hikurangi, the East Cape district, and Tokomaru Bay.

The leaves of this species are very characteristic, their blades having a very narrow triangular form, tapering uniformly from the base to the tips. *D. strictum* Hk. f. has leaves of a similar shape, but these are much broader and more coriaceous. Its alliance is probably with some of the congeries of forms united in Cheeseman's *Manual* (first edition) under the collective name *D. Urvillei* A. Rich.

5. **Veronica Dartoni** sp. nov.

Frutex erectus, 21 dcm. altus v. ultra. Folia decussata, anguste lanceolata, 17–25 mm. longa, a medio 7–9 mm. lata, integra, glabra, ± complanata, leviter carinata, in basim sessilem sublatum attenuata et in apicem subacuminatum aequaliter producta, nervis duobus obscuris prope margines percursa. Racemi in foliorum superiorum axillis dispositi, ad 6 cm. longi, angusti, multiflori, pedunculati (pedunculis quam folia ter longioribus, puberulis); rhachide pedicellisque firme pubescentibus; bracteis pedicellos aequantibus, ovato-lanceolatis, acutis. Flores majusculi, roseo-caesii; calyx 4-partitus, lobis lanceolatis acutis ciliolatis; corollae tubo sublato, calycis lobos paullo excedente; limbo ± 9 mm. lato, lobis ovatis acutis multinerviis tubum longitudine vix excedentibus, capsula glabra, acuta, ± compressa, calyce subduplo longior.

An erect branching shrub, 7 ft. high or more; branches slender, terete, glabrous, brown, closely ringed by scars of fallen leaves. Leaves decussate, overlapping, spreading, narrow lanceolate, contracted towards rather broad sessile base and produced into subacuminate tips, ¾–1 in. long, ¼–⅓ in. broad at middle, entire, glabrous, more or less flattened, rather thin, slightly keeled, midrib somewhat depressed above, traversed by two obscure sublateral veins, otherwise nerveless. Racemes in 2–3 opposite pairs in axils of uppermost leaves, up to 2⅜ in. long including peduncles, rather narrow, closely many-flowered; peduncles about as long as leaves slender puberulous; rhachis and pedicels strongly pubescent; bracts equalling pedicels, about 2 mm. long, ovate-lanceolate, acute. Flowers rather large, "rosy lilac" (Darton); calyx 4-partite, lobes lanceolate, acute, ciliolate, corolla-tube rather broad, slightly exceeding calyx, limb ± ⅜ in. across; lobes ovate, acute, many-nerved, scarcely longer than tube. Capsules glabrous, acute, somewhat compressed, barely twice as long as the calyx.

Hab.—Firewood Creek, near Cromwell, Vincent County: D. P. Rocky banks of Clutha River near Roxburgh bridge: Brian Jeffery! H. L. Darton! Queenstown Hill (Lake Wakatipu): J. W. McIntyre.

This plant is named in honour of Mr. H. L. Darton, of the Lawrence High School, who, in conjunction with Mr. H. Hart, has done so much to create public interest in the varied forms of this genus. The Firewood Creek specimen was collected in 1911; the additional plants were discovered only two or three years ago. Mr. Darton mentions that it is a most beautiful object when in flower, and very floriferous.

6. **Veronica trifida** sp. nov.

Species *V. Birleyi* (N. E. Brown) affinis; differt habitu prostrato v. decumbente late diffuso; ramis ramulisque elongatis (ad 90 cm. longis v. ultra); ramulis demum ab apicibus ± suberectis; foliis subalte 2-4 dentatis, politis, pro parte maxima glabris; racemorum pedunculis longioribus (9 mm. longis), pedicellis 1·5 3 mm. longis.

A prostrate or decumbent slender twiggy plant, forming extensive sheets or patches on wet ground, mostly alongside melting snow-drifts: branches slender, more or less matted, laxly subdivided, tips ascending or suberect, rooting for much of their length, more or less clothed by remains of decayed leaves, up to 3 ft. in length. Leaves closely imbricating, appressed or somewhat spreading, sessile by a broad base, roughly obovate in general outline, 7–8 mm. long and about half as wide, obtuse, polished above and below, slightly incurved at edges more or less concave above, coriaceous, not keeled, glabrous but for scattered hairs on edges and near base, usually shortly trifid near apex with broad terminal lobe and two prominent acute teeth a little below, but sometimes with two pairs of similar teeth above middle, in younger states frequently entire. Racemes 1 3 in axils of upper leaves, few-flowered, pedunculate, peduncles densely glandular-pubescent, ± 9 mm. long, pedicels 1·5 3 mm long, clothed like the peduncles as are also bracts and calyx; bracts a single pair a little below flowers, lanceolate, thin, subacute; calyx 4-partite, lobes thin acute; "corolla pure white, $\frac{1}{2}$–$\frac{3}{4}$ in. across, segments rounded, tube long" (Darton); capsule almost equalling sepals, subcuneately obcordate, much compressed, 4–5 mm. long, 3 mm. wide, glabrous.

Hab. -Titan Ridge, near the Blue Lake, Garvie Mountains, Southland, *circa* 4,500 ft.: J. Speden! H. L. Darton!

The leaves of this plant show a wide range of variation. Its mode of growth may be gathered from the following extract from a letter to me from Mr. Speden: "It is a plant found or seen only below the edges of snow-drifts or where these have been. It has rather lax growth, the small stems being flattened down on the ground with the weight of the snow and the leaves rotting off. As the snow melts in the late spring or early summer it makes fresh erect growth rapidly up to 6 in. or 9 in., but generally 3 in. or 4 in. only. On one trip I noticed a band of white about 1 yard wide and 40 or more yards long below a snow-drift, and on examining it found below the white band taller plants past flower and in seed-pod for 3 or 4 yards lower down. Higher up it was just coming into flower, and in all intermediate stages to the edge of the snow."

As I have not seen the plant growing, I feel that the foregoing description must be in many respects inadequate.

The Vegetation of Banks Peninsula: Supplement 1.

By Robert M. Laing, M.A., B.Sc., F.N.Z.Inst., and A. Wall, M.A.,
Professor of English, Canterbury College, Christchurch.

[*Read before the Philosophical Institute of Canterbury, 7th November, 1923; received by Editor, 16th November, 1923; issued separately, 30th July, 1924.*]

This paper contains (1) an account of the forest in Price's Valley, perhaps the only remnant of any importance of the lowland forests of the peninsula; (2) a list of such plants (about thirty) as have been found for the first time on Banks Peninsula since the original paper was published, together with the names of those that have to be removed from the *species inquirendae* or *species excludendae* and added to the list of still existing species; (3) a list of such new habitats discovered by us as seem worthy to be put on record. The list does not include such habitats as have been recorded by other observers since the original paper was written. Few dicotyledons have been added, showing that the original list of these was nearly complete.

The abbreviations of collectors' names is as before:—

A. W. .. Professor A. Wall.
W. M. .. Mr. William Martin.
R. M. L. .. Mr. R. M. Laing.
L. C. .. Dr. L. Cockayne, F.R.S.

I. THE FOREST, PRICE'S VALLEY.

Price's Valley lies between Kaituna Valley and Little River, and contains one of the few remnants of lowland forest still existing in a state of good preservation, and probably the best stand of black and white pine now to be found on the peninsula. Since publication of the previous paper* opportunity has been found of examining more closely than heretofore the vegetation of this valley. We are thus enabled to form a better picture of the original lowland forest of Banks Peninsula.

The Banks Peninsula Botanical Subdistrict might be defined in many ways. Thus a sufficient discrimination of it would be a district in which *Alectryon excelsum* and *Olearia fragrantissima* occur together; but, though this would separate it probably from all other forest areas of New Zealand, the description would be of little value to the botanist, as *Olearia fragrantissima* is a rare and disappearing species. One might rely, however, on other species for a separation. It is doubtful, for example, whether the following species could be found commonly together elsewhere—*Nothopanax anomalum*, *Teucridium parviflorum*, *Pseudopanax ferox*— as they can be in the district between Gebbie's Pass and Little River. Again, Banks Peninsula might be defined as being characterized by the presence of certain northern species and the absence of others. Thus the following species might be expected to occur and do not: *Cordyline Banksii*, *Melicope ternata*, *Olea Cunninghamii*. Their absence separates the forest here from that on the Kaikoura coast, which it most nearly resembles; and the presence of the karaka and the nikau-palm distinguishes it from the tree-clad districts farther south. From these and from other similar considera-

* *Trans. N.Z. Inst.*, vol. 51, p. 355, 1919.

tions it becomes clear that the forest of Banks Peninsula is sufficiently characteristic to be regarded as a separate sub-area. It is so considered by Cockayne in his *Vegetation of New Zealand* (p. 138).

At present, however, owing to the almost complete destruction of the original plant covering by fire, and in other ways, it is difficult to find means for reconstructing in imagination the original plant associations. Fortunately, in Price's Valley there is still a remnant of the primitive forest left on the valley-floor, through which neither fire nor sawmill has been, though, unfortunately, stock have run in it; and there is also a portion of the same forest at the head of the valley at an altitude of 1,500 ft. and upwards. We know of no other place on the peninsula where fragments of the lowland and upland forest are left in a state of such good preservation in the same valley. This enables us to confirm more definitely certain conclusions regarding the forest, arrived at tentatively before.

From this area it appears that the large trees on the valley-floors of the peninsula were chiefly black and white pine with a comparatively small admixture of totara. As the valley narrowed the black and white pines were replaced by totara, which constituted the chief timber-tree of the hillsides. Above 1,500 ft. *Podocarpus totara* became rarer, and plants of *P. Hallii* appeared, and soon predominated. At the same altitude occasional plants of *Libocedrus* were to be found. In the valley referred to there is a great break, however, in the forest between about 200 ft. and 1,000 ft., where now nothing but second growth occurs, so that the changes cannot be followed in detail.

In the lower forest there is a great variety of shrubs, including such plants already mentioned as are elsewhere rare in company—*Teucridium*, *Pseudopanax ferox*, *Nothopanax anomalum*, *Melicytus micranthus*. Several specimens of *Olearia fragrantissima* were observed at a somewhat higher altitude. *Pseudopanax ferox* is replaced by *P. crassifolium* below 1,000 ft., and *Rubus australis* becomes much more abundant, while the huge lianes of *R. cissoides* are no longer to be seen. The point where the kahikatea originally passed out of the forest cannot now be determined, but probably it was below 1,000 ft. Above this the forest takes on the characteristics of the totara association described in the previous paper.

II. PLANTS TO BE ADDED TO THE LIST OF EXISTING SPECIES.

FERNS (FILICES).

Hymenophyllum demissum Swartz.
Bush at the head of the Kaituna Valley on Mount Herbert: A. W.

Trichomanes humile Forst.
Edge of stream, Paua Bay: R. M. L.

Alsophila Colensoi Hook. f.
Price's Valley, common in the bush above 1,500 ft: R. M. L. Head of Stony Bay: W. M.

Hypolepis distans Hook.
Near Akaroa: W. M.

Blechnum Banksii Hook. f.
Akaroa Lighthouse: A. W.; L. C. Stony Bay: W. M.

Blechnum vulcanicum Kuhn.
Grehan Valley, Akaroa: W. M. Mount Pleasant, Lyttelton: A. W.

Pteris tremula R. Br.
Peraki Reserve, Little Tikao Bay: W. M.!

Asplenium bulbiferum Forst. var. *tripinnatum* Hook. f.
Takamatua, Waikerikikeri, Brasenose: R. M. L.

Polystichum capense J. Sm.
Wainui, common in Grehan Valley: W. M.!

Nephrodium velutinum Raoul.
Akaroa, Wainui, Price's Valley: R. M. L.

Polypodium Cunninghamii Hook.
Near the stream Paua Bay: R. M. L. I was pleased to get this, as it is another plant to be added to the list of those reaching their southern limit on Banks Peninsula.

For other species of Filices said to have been gathered by Mr. D. G. Riches on Banks Peninsula, see Martin, *Trans. N.Z. Inst.*, vol. 52, p. 315. As Riches is known to have received many species from the North Island, the evidence of his herbarium is to be accepted with reservation.

Family GRAMINEAE.

Agrostis parviflora R. Br.
Bush and base of rocks, Mount Herbert: A. W.

Deyeuxia Petriei Hack.
High grassland, Mount Herbert: A. W.

Deyeuxia avenoides Buch.
Mount Herbert: A. W. The type and var. *brachyantha* are both abundant.

Danthonia nuda Hook.
Mount Herbert, 1,500 ft. and upwards: A. W.

Danthonia semiannularis R. Br. var. *setifolia* Hook. f.
Rocks above Purau, east side, 2,000 ft.: A. W.

Danthonia semiannularis R. Br. var. *nigricans* Petrie.
South and west slopes of Mount Herbert, near summit: A. W.

Koeleria Kurtzii Hack.
Mount Herbert from 2,000 ft. to summit, Port Hills: A. W.

Poa Lindsayi Hook f.
Saddle Hill, Redcliffs Spur: A. W.

Poa Kirkii Buch.
Mount Herbert: A. W.

Poa anceps Forst. f.
Mount Herbert, near the summit: A. W.
Professor Wall has grown this at Fendalton, and at this low level it maintains its characteristics, and shows no tendency to revert to *P. caespitosa*.

Festuca rubra Linn.
This very difficult species should have been included in the previous list. It is not uncommon in pastures, and perhaps is only a form of *F. novae-zelandiae* (Hack.) Cockayne. A distinct form occurs on the south and west faces of Mount Herbert near the summit (Kaituna side).

Family CYPERACEAE.

Carex Solandri Boott.
Bush, Mount Herbert: A. W.

Carex testacea Sol. ex Boott.
Redcliffs Gully: A. W. Akaroa: R. M. L.

Family JUNCACEAE.

Juncus prismatocarpus R. Br.
Ditch by the side of the road, Kaituna Valley. Motueka Valley is the southernmost locality given by Cheeseman, but it occurs at least as far south as Peel Forest: R. M. L.

Family LILIACEAE.

Bulbinella Hookeri Benth. & Hook.
Summit Road at head of Le Bon's Bay: W. M.

Dianella intermedia Endl.
I was surprised to find a few drought-stricken specimens of this plant in a cleft on the rocks on the northern face of Marley's Hill (May, 1922): R. M. L. On rocks, Charteris Bay: Orton Bradley.

Family POLYGONACEAE.

Muehlenbeckia ephedrioides Hook. f.
It is perhaps worth while putting this on record; though not strictly a Banks Peninsula plant, yet it occurs close to the foot of the hills. Outlet to Lake Forsyth: W. M.; R. M. L.

Family RANUNCULACEAE.

Clematis marata Armstr.
Amongst manuka scrub, Charteris Bay: Orton Bradley!

Family ROSACEAE.

Geum parviflorum Smith.
Rocks on the south side of Mount Herbert, near the summit: A. W. Another addition to our subalpine flora.

Family VIOLARIEAE.

Melicytus micranthus Hook. f. var. *microphyllus* Cheesman.
Price's Valley, on the flat; one plant only seen: R. M. L.

Family RUBIACEAE.

Nertera setulosa Hook. f.
Mount Herbert, 2,500 ft.: A. W.

Family. COMPOSITAE.

Gnaphalium Traversii Hook. f.

Bog near the top of Castle Hill. This is now to be added to the list of subalpine species: R. M. L.

Senecio Lyallii Hook. f.

Mount Herbert, south side, about 2,800 ft.: A. W. An unexpected subalpine plant.

Taraxacum magellanicum Comm.

Mount Herbert, near summit, both sides: A. W.

CRITICAL SPECIES.

Myosotis australis R. Br. var. *lytteltonensis* (Laing and Wall) var. nov. (Text-figs. 1–3.)

Ramis decumbentibus vel prostratis, crassioribus, rachide multo-breviore quam in forma typica; stylo filiformi gracili, aequanti corollae tubo in longitudine, nucellis maturis nigris nitentibus, leviter ochratis vel fulvis, non subferrugineis.

In the previous list was mentioned among the critical species a form of *M. australis* with the habit and external appearance of *M. Forsteri*. It seems sufficiently distinct and local to require a varietal name. The following is a somewhat fuller description:—

Plant biennial. Stems branched from root, decumbent or prostrate or ascending at tips, stout and scarcely flaccid, 6–18 in. long, hispid with straight or more or less appressed hairs, lower leaves on rather stout petioles 2–3 in. long petiole 1 2 in. long, sheathing at base; blade 1·2 in. long, oblong to spathulate, obtuse or apiculate, rather membranous, margins and midrib hispid, and both surfaces hispidulous. Racemes somewhat elongated, pedicels $\frac{1}{10}$ in. long, rather stout, many-flowered. Flowers white, or white with yellow eye, $\frac{1}{4}$-$\frac{1}{3}$ in. long, $\frac{1}{4}$ in. in diameter. Calyx tubular in flower, becoming campanulate in fruit, hispid with spreading sometimes hooked hairs, five-lobed to beyond middle, lobes linear to linear-lanceolate acuminate. Corolla-tube funnel-shaped and nearly twice length of calyx, throat with five scales; lobes short, rounded. Anthers included, their tips barely equalling corolla-scales. Style much longer than calyx and equalling corolla-scales. Nutlets ovoid not orbicular, length about $1\frac{1}{2}$ times breadth, when ripe shining-yellowish or greyish-black not pale brown.

The plant has much more resemblance to *M. Fosteri* than to *M. australis* in its exterior appearance; but in the details of its structure it comes much nearer to the latter. It differs from *M. australis* in being decumbent or prostrate, in the much less elongated rachis, in the long style, and in somewhat lighter colour of the nutlets.

From *M. Forsteri* it differs in being much stouter and stiffer, in the calyx being divided nearly three-quarters of the way down, in the elongated corolla, the shape of the nutlets, and perhaps also in their colour. It apparently bears considerable resemblance to *M. australis* var. *conspicua*, which, however, is unknown to us.

Hab.—Cliffs above Lyttelton, Governor's Bay, and Sumner Road.

Anisotome Enysii (T. Kirk) Laing.

We can find none but trivial differences between this and the Castle Hill plant. In the Banks Peninsula form the bracts are rather narrower, longer, and more acute, and nearly connate.

Myosotis australis var *lytteltonensis* n var

FIGS. 1, 2.—Parts of plants; half natural size. FIG. 3.—Section of flower.

ERRATA.

The following species were admitted into the previous paper in error, and the names should therefore be deleted from the list.

Cyathea Cunninghamii Hook. f.

The plant from Cooper's Knobs is no doubt *Hemitelia*. However, I have reintroduced the species for a plant from Peraki Reserve, on the authority of Dr. Holloway. This has the complete indusium of *Cyathea*. —R. M. L.

Festuca multinodis Petrie.

No form of *Festuca* in this neighbourhood is anything like Petrie's plant, which is very distinct. Very few individuals of *F. novae-zelandiae* have even three nodes. A. W.

Scirpus antarcticus Linn.

Is recorded in error for *S. aucklandicus* Boeck, by which it should be replaced.

Carex flava Linn. var. *cataractae* R. Br.

I have recorded this from Castle Rock; but I find on examining my herbarium again that there is possibly a mistake in the locality. The species should therefore be removed from the list, pending confirmation of the locality.- R. M. L.

Libertia grandiflora Sweet.

This is probably only a form, though a distinct form, of *L. ixioides*.

Plantago spathulata Hook. f.

This is an erroneous identification of *P. Raoulii* Decaisne.

A Chemical Investigation of Pintsch Oil.

By H. J. Finlay, M.Sc., Edmond Fellow of Otago University.

[*Read before the Otago Institute, 12th December, 1922; received by Editor, 31st December, 1923; issued separately, 30th July, 1924.*]

It is well known that the cracking of saturated oils leads to very complex products, which are generally highly unsaturated and very volatile. The gases obtained are of high illuminating-power, and have long been used by various railway companies for this purpose. In New Zealand, kerosene (density 0·860), on cracking, yields such a gas, which is known as Pintsch gas, and at the same time a quantity of tarry matter, and the gas itself on compression into the storing-cylinders deposits a surprisingly large amount of water and a considerable amount of a crude light oil which may be appropriately designated Pintsch oil. At present the only commercially important product of this cracking is the illuminating-gas, the only use to which the Pintsch oil is put being in carburetting gases of low illuminating-power, and to a slight extent in preventing napthalene from crystallizing in gas-pipes. Apart from this it is practically wasted, and, as about 15,000 gallons are produced annually, it becomes a matter of commercial importance to find some use for it.

The oil at present is unfit for commercial use because of its stench, its extreme volatility and inflammability, and especially its property of depositing a gummy layer on all vessels in which it is kept. If it were not for this last objection the oil would make an excellent motor-spirit.

Armstrong and Miller have published a paper (*J.C.S.*, 1886, vol. 49, T., 74) on "The Pyrogenesis of Hydrocarbons," in which an oil similar to Pintsch oil is described. In their oil they showed the presence of paraffins, naphthenes, olefines, pseudacetylenes, and aromatic hydrocarbons, ethylene, butadiene, and benzene being the chief constituents.

The Pintsch oil itself is light-yellowish and very mobile possessing a nauseous, persistent smell, similar to crude acetylene. It contains large amounts of dissolved gases which are expelled on warming, the liquid beginning to boil at 35° C. and distilling irregularly up to about 112° C., at least half of the oil being benzene, and another quarter toluene. All the fractions, more especially the lower ones, are highly unsaturated. Above 112° C. the residue rapidly darkens, and decomposes spontaneously with evolution of pungent-smelling white fumes.

Oxidation with permanganate of a fraction boiling between 60° and 90° C. yielded formic and probably butyric acids, thus indicating the presence of *n*-amylene in the original oil, in agreement with Armstrong and Miller's conclusions.

As it was thought that the "gumming" of the oil would probably be due to polymerization of the unsaturated hydrocarbons present, experiments were carried out with a view to increasing the speed and amount of the action. The action of sodium wire at 60° C., in a sealed tube, was tried on the original oil, and on a fraction consisting mostly of butadiene (obtained by condensing Pintsch-oil vapour by means of a freezing mixture). There was no perceptible action with the oil itself, but the low boiling-fraction gave a considerable quantity of a soft rubber-like mass, differing in its solubilities from true rubber. It was probably a polymer which had not reached the rubber stage.

Most of the work done on the chemistry of the oil was performed on bromides obtained from the various fractions. To obtain these without excessive decomposition it is essential that the addition of bromine should be cautious and slow (liquid bromine is too vigorous; dropping bromine through a layer of bromine water was tried, but the best results were obtained by the gradual mixing of the vapours from Pintsch oil and bromine), and the reaction-flask be constantly cooled by a stream of water. The method adopted was to pass the vapour obtained by warming a large quantity of Pintsch oil into ammoniacal silver-nitrate solution, then into the absorption-flask (containing a layer of liquid Br_2), then through another small quantity of Br_2 to catch any escaping unsaturated gas, then through a bubbler of NaOH solution, and finally into a cylinder where the residual paraffinoid gas was collected by downward displacement. Even with all precautions to guard against overheating, each shaking of the absorption-flask caused a torrent of HBr fumes to rush over (the reason for the formation of this substance is not apparent); the bromides in the absorption-flask, though at first clear, gradually turned dark brown, and much decomposition occurred. The chlorides and iodides, which were also prepared in small amount, showed the usual gradation of properties, the order of decreasing stability being chloride, bromide, iodide. The iodides decomposed at once, producing a carbonaceous residue and methyl iodide.

When the absorption-flask became quite cold the contents practically solidified. The liquid bromides were slowly filtered off, using a Buchner funnel, and the solid bromide, after recrystallization twice from alcohol, was obtained as a pure-white, powdery mass, appearing under the microscope as very irregular tables with a few short and thin prisms (M.P. 113° C.; Br percentage, by Stepanow's method, 85·9). This is in good agreement with the data obtained by Armstrong and Miller for their solid butadiene tetrabromide, so that the more volatile parts of Pintsch oil consist largely of butadiene. This solid bromide is extremely stable to most reagents. Alcoholic potash, zinc-copper couple in boiling alcohol, and boiling concentrated nitric acid have alike very little action on it. The vapours of both the liquid and solid bromides have an extremely irritating effect on the eyes.

Large quantities of the liquid bromides were prepared and fractionally distilled at atmospheric and at reduced pressure. Purification proved difficult, but repeated distillations at length yielded 40 c.c. of a clear colourless fraction (B.P. 58 66° at 23 mm.; density, 1·825 at 13° C.) which remained stable on keeping. The substance was very refractory in combustion, the values finally obtained being C, 21·1 per cent.; H, 3·5 per cent. Analysis* (Carius method) gave 75·9 per cent. bromine, so that the fraction was probably a slightly impure specimen of butylene dibromide. (Calculated percentages- C, 22·2 per cent.; H, 3·7 per cent.; Br, 74 per cent.) Thus butylene is present in considerable amount in the lower boiling fractions of Pintsch oil, so that the liquid dibromides that Armstrong and Miller lost by fire would probably have yielded them butylene on treatment with zinc-copper couple, thus completing their list of olefines present. The question as to which of the butylene isomers this substance is was not definitely settled, but probability points to the normal olefine.

The liquid bromide, also, is very unreactive, KOH (alcoholic and 30 per cent. aqueous), HNO_3 and KCN having very little effect. Zinc-dust or zinc-copper couple in alcohol reduces it, $SbCl_5$ liberates bromine, PCl_5 dissolves without action. Anhydrous $AlCl_3$ has a rather peculiar action, which is the same with the pure bromide or its benzene solution. Clouds of HBr are given off, and a dark-brown oil,† insoluble in benzene, is formed.

Further fractions of the Pintsch oil were brominated, and one boiling between 55° and 65° gave evidence of the presence of amylene and hexylene, in agreement with the results found by Armstrong and Miller, who used an oxidation method.

In the preparation of the bromides by the method already detailed it was found that the ammoniacal silver-nitrate solution, through which the vapour from the Pintsch oil was passed, rapidly turned black, while a copious precipitate formed. This is in direct opposition to the results recorded by Armstrong and Miller, and indicates that true acetylenes are present in at least the lower fractions of Pintsch oil. The gas that passed

* The Stepanow method, which was previously tried, gave results which, though consistent, were always about 14 per cent. low, so that the method is not always reliable. Later experiments showed that correct results could be obtained only by using double the quantity of sodium recommended by Bacon, and prolonging the time of adding the sodium and of the subsequent refluxing.

† This oil is decomposed by water, yielding a light-yellow oil with fragrant odour, strongly fluorescent in ether, alcohol, or acetone solution. The violet fluorescence of the pure oil disappears on heating, but returns in the cold. It contains no bromide or aluminium. This action is very remarkable, simulating as it does the Friedel and Craft reaction, which, however, is supposed to be restricted to aromatic substances.

through all the absorption-solutions and finally collected in the storing-cylinder was very small in amount, and consisted mostly of air driven out of the apparatus, indicating that paraffins or other saturated constituents are present in the volatile fractions in only very slight amount.

A considerable amount of work was done to determine the possibility of a commercial use for the oil, but in the following brief summary all details are omitted, and only the main results indicated. The chief objections to the oil are its smell, and its tendency to form a gum on standing, and so clog the engine-valves; both these effects are possibly due to the higher unsaturated fractions. Distillation of the dry oil up to 100° C. gave a 60 per cent. fraction which apparently did not gum after standing for some months, but which still made a poor motor-fuel (as tried in a motor-cycle). The best effects were obtained with equal parts of petrol and Pintsch oil, but extensive trials are needed in this direction.

The effect of various catalysts and other reagents in reducing the unsaturation (and therefore, presumably, the gumming, &c.) was tried, but with discouraging results: boiling under reflux condenser with alcoholic sulphuric acid, and subjecting to the catalytic action of freshly reduced iron and nickel at various temperatures up to 340° C., producing little effect. Aluminium chloride, a reagent that has frequently been used for treating unsaturated oils, had a decided action (increasing with the boiling-point of the fraction used), producing a viscid, pitch-like polymerization product, soluble in organic solvents, containing no aluminium, and with no taste. In spite of this action, however, the distillate of volatile oil was still highly unsaturated, and its bad properties had not been markedly reduced.

Since benzene forms the largest constituent of the oil, it was thought that immersion of the oil in a freezing mixture might induce separation of crude benzene crystals. No such effect was, however, observed, nor could solid benzene be obtained even by similarly treating fractions in the neighbourhood of 80° C., though crystals of pure benzene were repeatedly introduced while the temperature was −20° C.; in fact, the crystals readily dissolved up. If the oil is previously treated with concentrated sulphuric acid to absorb the unsaturated constituents, fractions in the neighbourhood of 80° C. readily yield solid benzene on freezing, but there is apparently no hope of obtaining it easily from the original oil.

In conclusion, the writer wishes to thank Dr. Inglis for his help and advice during the investigation.

Three Fossil Annelids new to New Zealand.

By H. J. Finlay, M.Sc., Edmond Fellow of Otago University.

[*Read before the Otago Institute, 10th July, 1923; received by Editor, 31st December, 1923; issued separately, 30th July, 1924.*]

Some specimens of Annelid tubes from the Moeraki boulders were lately brought to me by Professor Park for examination, and description should they prove new. The discovery is interesting, as hitherto these beds have yielded no fossils beyond a fragment of avian or reptilian bone. Professor Park informs me, however, that in places the outer crust of the boulders contains numbers of these Annelid tubes. All the specimens are very poor, and, as the matrix is hard, even good fragments are difficult to obtain. It is thus impossible to state either the length or amount of curvature of perfect tubes, but, so far as can be seen, the test, though irregular in its course, is fairly straight. No fragments definitely referable to the anterior or posterior end have been seen, so that it is not known whether any constriction in the tube or thinning of the walls occurs. Mr. F. Chapman, A.L.S., Palaeontologist to the National Museum, Melbourne, who also saw the specimens, informs me that the species is "more solid and apparently longer than *Ditrupa cornea* var. *wormbetiensis* McCoy, of the Janjukian of Victoria."

Ditrupa parki n. sp. (Fig. 1, *a*, *b*.)

Tube of moderate length, slender, and apparently slowly tapering; walls very solid, often nearly as thick as internal diameter of tube. Surface with distinct growth-lines, and 2 or 3 very indistinct, almost obsolete, broad, longitudinal ridgings. In one example is a single collar-like swelling.

Length of type (largest, but still very imperfect example), 7·5 mm. Exterior diameter of a large fragment, 1·75 mm.; interior diameter, 0·65 mm.

Type in author's collection.

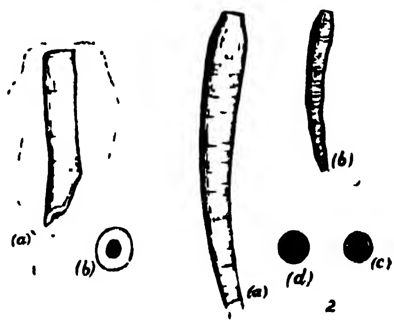

Fig. 1.—*Ditrupa parki* n. sp. *a*, type; *b*, cross-section of paratype.
Fig. 2.—*Ditrupa chapmani* n. sp. *a*, type; *b*, paratype; *c*, end view of aperture of type; *d*, cross-section through paratype.

The age of the locality is uncertain. Marshall (*Trans. N.Z. Inst.*, vol. 49, 1917, p. 463) in his account of the Hampden beds makes the following statement: "The fossiliferous [Hampden] beds rest directly on the strata that contain the well-known Moeraki concretions. These pass downward into the concretionary but more sandy Kartigi beds, which in turn rest on the Shag Point conglomerates that contain the coal. Above the fossil-bearing beds there are the volcanic tuffs and breccias called the Waiareka tuffs; these in turn lie below the Oamaru limestone." The Hampden beds are thus below the Waiarekan, and contain a fauna which shows that they are closely related to the Waihao greensand beds at McCullough's Bridge, which in turn are at a higher horizon than the "Island sandstone"

or Bortonian beds at Black Point and Kakahu. The Shag Point beds have been doubtfully referred to the Piripauan by Thomson (*Trans. N.Z. Inst.*, vol. 52, 1920, p. 385), and the only stage at present distinguished between Bortonian and Piripauan is the Kaitangatan. The Kartigi and Moeraki beds therefore presumably represent the Kaitangatan and Bortonian stages, so that the "boulders" are probably of low Eocene age; in the absence of fossils, further speculation is useless.

Ditrupa chapmani n. sp. (Fig. 2, *a*, *b*, *c*, *d*.)

Tube rather long and very slender, gently tapering; perfect juvenile specimens have very much the appearance of *Cadulus delicatulus*, being of about the same proportions but slightly less curved and of different texture. The curvature is distinct but not great, more pronounced posteriorly. No swelling at the anterior end, but the test reaches greatest width a short distance from aperture and thence markedly contracts to thin and sharply-edged circular orifice. Surface appears smooth, but under the glass presents a coarse texture and minutely-corrugated appearance due to very numerous and rather regular growth-lines, forming rings that are always fine and never resemble collars. The outlines are almost always perfectly regular, but in one or two cases there are a few gentle swellings near posterior end of juvenile shells, but never, in adults, at the anterior end. Colour of shell pale brown with rings and bands of greyish. The cross-sections of broken specimens show that the internal orifice is always circular, but may be central or distinctly excentric; there is an inner narrow whitish ring, then a thick brownish crystalline layer with a radiating appearance, then finally a very narrow surface-layer.

Dimensions of type: Length, 12·5 mm.; greatest width (just behind aperture), 1·25 mm.; width of posterior (broken) end, 0·8 mm.; diameter of orifice, 0·85 mm.

Type, from Clifden, Southland (band 6c—Ototaran ?), in author's collection. Most plentiful and of best preservation in this band, but occurring also in several other bands at that locality.

Of much more elegant appearance, greater tenuity, and more gradual taper than *D. cornea* var. *wormbetiensis* McCoy, typical examples of that species being considerably shorter, yet much wider than the new species. The absence of anterior nodosities separates it at once from the var. *constricta* Chapman. Named after Mr. Chapman, of the National Museum, Melbourne who has always readily given his assistance on this and other occasions.

Serpula ouyenensis Chapman.

Described from the Kalimnan (?) and Janjukian of the Mallee Bores, Victoria (*Proc. Roy. Soc. Vict.*, vol. 26, n.s., p. 182, pl. 18, figs. 24, 25; pl. 19, fig. 42; 1913). Mr. Chapman identified as this species specimens of a *Serpula* from the road-cutting at Pukeuri (Awamoan); the shell is quite common at that locality, but the specimens are exceedingly fragile, and only small pieces can be obtained. Specimens that seem also referable to this species are commonly found in several of the bands at Clifden, Southland, but more especially band 6c. This horizon is considerably lower than Awamoan, and may well be Lower Miocene or even Oligocene, so that the species would seem to have an earlier occurrence in New Zealand than in Australia, and, if the Australian records are included, a considerable range. This, however, is of frequent occurrence in the Annelids.

New Shells from New Zealand Tertiary Beds.

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Plates 48–51.

The following forms are described from the new material in the author's collection; many of them are related to Australian species, and others represent genera new to the New Zealand fauna. Notes on some already-described species are also given.

Natica notocenica n. sp. (Plate 49, figs. 2*a*, 2*b*, 2*c*, 2*d*.)

N. zelandica Suter (in many lists of fossils from Miocene localities), not of Q. & G.

Shell small but solid, smooth and polished, exceedingly glossy when well preserved, globosely ovate, with strong funicle in umbilicus. Surface almost quite smooth, growth-lines inconspicuous, curving away from suture; faint spiral scratches occasionally noticeable. Spire low, regularly conical, bluntly pointed. Protoconch paucispiral, depressed, hardly differing from later whorls. Whorls 4½ 5, base regularly convex. Suture slightly canaliculate only for two apical whorls, thence inconspicuous, whorls tightly clasping those above without sutural flattening, so that sides of spire are perfectly straight. Aperture semilunar, oblique. Outer lip loop-shaped, very thin and sharp, but rapidly becoming thicker internally, ascending somewhat on penultimate whorl before joining inner lip. Columella oblique, almost straight, slightly excavated posteriorly. Inner lip spreading only slightly as rectangular lip over parietal wall, and as very thick semicircular funicle into moderate umbilicus, often almost filling it, though a deep chink is always left above funicle. Outer edge of umbilicus very bluntly carinate and separated by deep groove from funicle, surface of which is corrugated by strong folds inside, and ends in a wide, concave flattening. Operculum unknown.

Height, 7·5 mm.; diameter, 7 mm. (type). Height, 11 mm.; diameter, 10·5 mm. (largest specimen, from Target Gully).

Type, from Awamoa (blue clays on banks of stream), in author's collection. Common at Ardgowan, Target Gully, and Pukeuri; specimens also from Pareora, Rifle Butts, Kakanui tuffs, Waikaia, and McCullough's Bridge, Waihao—*i.e.*, throughout the Oamaruian.

This species has always been identified as *N. zelandica* Q. & G., but it is totally different in its constantly smaller size, heavier umbilical callosity (though this varies in strength in both species), and especially in shape of spire, which in *N. zelandica* is slightly scalar, due to the infrasutural flattening, but in *N. notocenica* is perfectly conical, except in some senile examples where the whorls bulge out a little. At most Oamaru localities this species is accompanied by the following one, but has a much longer range in earlier horizons. No difference at all can be picked between Waihao and Pukeuri specimens.

Natica consortis n. sp. (Plate 49, figs. 1*a*, 1*b*, 1c.)

Shell small, moderately solid, smooth and polished, somewhat vertically compressed, with moderate umbilical funicle. Sculpture and protoconch as in *N. notocenica*. Spire low, subscalar, flattened at apex. Whorls 4½–5, base flatly convex. Suture as in preceding species for first two whorls, but thence quite different, whorls being abruptly turned inwards near suture, forming round it a perfectly flat rather wide platform, so that spire appears staged; this platform widens considerably as growth proceeds. Aperture pear-shaped, narrower above and wider below than in *N. notocenica*. Outer lip forming a wider loop than in that species, thin and sharp, not ascending on penultimate whorl, but extending forwards past columella before joining inner lip. Columella oblique, not nearly so straight as in *N. notocenica*, considerably excavated below before meeting outer lip. Inner lip spreading less, both on parietal wall and into umbilicus, than in the previous species. Funicle cord-like, not strong, marked off by groove below, and leaving wide opening above, much less corrugated than in *N. notocenica*, and ending in a slight convex lump. Operculum unknown.

Height, 8·5 mm.; diameter, 8·5 mm. (type). Height, 10·5 mm.; diameter, 9·5 mm. (largest specimen from Ardgowan).

Type and three others, from Pukeuri, in author's collection. Common at Ardgowan; specimens also from Rifle Butts, Target Gully, and Awamoa (from beach-boulders).

This species has a slight resemblance to *N. maoria* Finlay (*australis* Hutt., not of d'Orb.), but the funicle in the umbilicus at once distinguishes it. From its accompanying but commoner relative *N. notocenica* Finlay it is sundered by its weaker and different funicle, less ovate shape, and especially by its flatly bordered sutures. This last feature and the weak funicle separate it also from *N. zelandica* Q. & G., which has the whorls much more flattened into the sutures than in *N. notocenica*, but much less so than in *N. consortis*. Ardgowan and Target Gully specimens of both these species are always weathered and have lost their gloss; the sutures generally remain unweathered in *N. notocenica*, but in *N. consortis* are generally weathered to a canaliculate form. Unlike *N. notocenica*, this species does not extend to the Waihao horizon, being represented there by the following (probably ancestral) form.

Natica praeconsors n. sp.

This in most details is so similar to the preceding species that a full diagnosis is unnecessary, and only points of difference need be mentioned. The only three examples seen are of smaller size, much thinner, with whorls a little more globose, and base more rounded. Columella very weak, strongly curved, more excavated and S-shaped than in *N. consortis*. Umbilicus about same size, but appearing larger owing to extremely slight development of funicle, which is merely a very thin, subtriangular cord, hardly at all blocking opening, and widely removed from outer edge of pit. Sutures bordered by a flattened space, but not nearly so prominently as in *N. consortis*, outer edge of platform being rounded off into whorl.

Height, 7 mm.; diameter, 6 mm. (type).

Type, from greensands at McCullough's Bridge, Waihao, in Mr. R. S. Allan's collection.

Natica inexpectata n. sp.

This also is so close to *N. consortis* that it is best described by comparison with that species; the type is at present unique,* and further examples may show that it is worth only varietal rank. Early whorls are as in *N. consortis*, but sutural platform not quite so prominent. There are nearly 5 whorls, and on last platform tends to become obsolete, infrasutural outlines approaching those of *N. zelandica* Q. & G., to which species it is brought into nearer resemblance by the relatively large size of shell. Whorls much narrower, however, than in *N. zelandica*, but shape of these and of aperture is in accord with *N. consortis*. Funicle much stronger than in the latter species, three-parts filling the pit, and ending in a lightly convex flattening; very similar to that of *N. zelandica*.

Height, 15 mm.; diameter, 14 mm.

Type, from Clifden, Southland (band 7, Hutchinsonian), in author's collection

Polinices pseudovitreus n. sp. (Plate 49, figs. 3*a*, 3*b*, 3*c*, 3*d*.)

Polinices amphialus Wats.: Suter (in lists of fossils from Awamoan localities), not of Watson.

Shell small, porcellanous and slightly shining, rather thick, globosely elevated, spire conspicuous and scalar. Fine and close-set growth-lines; traces of very fine and close spirals. Spire rather high, varying from one-half to three-quarters height of aperture, strongly scalar, due to rectangular shape of whorls. Protoconch large, depressed and globose. Whorls 3½–3¾, the last very large and elongated, curving out almost horizontally from suture, then subvertical, finally rapidly contracted to convex and steeply-sloping base. The sudden change of direction from vertical to horizontal is marked by a rounded but bulging shoulder which throws spire-whorls into unusual prominence. Suture strong, often deeply grooved, a little sloping. Aperture pyriform, a little oblique, scarcely pointed above, usually less than two-thirds total height. Outer lip sharp and strong, patulous below. Columella straight. Inner lip expanded as a very definite and rather thick pad over parietal wall, with sometimes a slight tubercle just below outer lip; anteriorly the pad is flattened down over the narrow umbilicus, leaving only a small chink open. Front of columella very slightly flattened back on indistinct circumumbilical ridge.

Height, 8 mm.; diameter, 6·75 mm. (type). Height, 9 mm.; diameter, 7 mm. (largest specimen).

Type and seven others, from Rifle Butts, near Oamaru, in author's collection.

Closely related to *P. vitreus* (Hutt.) (= *P. amphialus* Wats.), but larger though of fewer whorls, sutures more deeply incised, much more exsert spire, and more prominently convex whorls. No specimens of this species have yet been found at the coeval locality of Pukeuri, but Mr. Marwick states that one specimen has been collected at Awamoa. At Pukeuri, Target Gully, and Otiake, however, there occurs another new species of *Polinices*, quite distinct from *P. pseudovitreus* in its larger umbilicus and flattened shoulder.

* Since the above was written the author has visited Otiake and there collected numerous specimens referable to this species, though mostly smaller in size. These show that the best features for differentiation from *N. consortis* are, as mentioned, the rounder sutural platform and the larger funicle, and also the more inflated appearance of the base, due to the more rapid descent of the last whorl.

Austrotriton maorium n. sp. (Plate 48, figs. 1, 2, 3; Plate 51, fig. 4.)

Cymatium minimum (Hutt.): Suter (in many lists of fossils from Awamoan and other horizons), not of Hutton.

Shell of moderate size, of irregular growth, spire staged, canal long. Protoconch of 3½–4 convex whorls, depressedly conic and very symmetrical, last half turn with 3 or 4 faint spiral keels, terminating abruptly in small varix and groove. Adult shells with 6 further whorls, later ones of very irregular growth, considerably swollen directly after a varix but contracted for short distance before one; spire-whorls carinate at about middle, shoulder of varying width (due to irregular growth), sloping at 45°, thence perpendicular to suture below; body-whorl subangulate, vertical space between sharp sutural and basal slopes being very short. Axial sculpture most prominent on this vertical part; usually 7 slight axial ribs between varices on early whorls, raised into prominent sharp tubercles on carina; on lower whorls are typically 5 strong, elongated, peripheral swellings between varices (which occur at about every three-fifths of a whorl), continued as faint ribs over shoulder and base, vanishing on canal. Swellings narrow, high, and blunt, but often tubercular at each extremity; last swelling considerably weaker than others, and on higher level, so that a distinct drop is apparent after each varix. On body-whorl are 4 main spiral cords, two marking peripheral angles and two below these, lowest in line with last denticle on outer lip; below these, strong and weak smooth cords alternate on canal. Between main cords are 3–6 finer cords cut up into elongated granules, shoulder with similar sculpture but cords wider apart just after a varix. Spire shorter than aperture with canal. Aperture suboval, a little oblique, channelled above, produced below into a canal equal in length to aperture and bent backwards to left. Outer lip sharp, with strong thick varix behind, also thickened internally and with 5 tubercles, the lowest at top of canal. Inner lip a little spreading, often with 2 or 3 small plaits on parietal wall. Columella strongly curved, with a few plaits at base, two much stronger than the others. A distinct umbilical chink generally present.

Height, 38 mm.; diameter, 21 mm.; height of aperture and canal, 22 mm. (type). Height, 25 mm.; diameter, 13 mm.; height of aperture and canal, 13·5 mm. (largest paratype).

Type, several half-grown, and many juvenile specimens, from Target Gully, in author's collection; also specimens from the following horizons and localities: Awamoan (Pukeuri, Rifle Butts, Mount Harris); Hutchinsonian (Otiake); Ototaran? (Clifden, bands 4, 6, and 7); Waiarekan? (Chatton).

This is the common "*Cymatium*" of Oamaru localities. Juvenile shells are met with at most of the collecting-grounds there, but the full-grown shell is apparently rare, the type and three more from Clifden being the only ones seen. It is of fairly constant appearance when large, but the canal varies considerably in length, especially in juveniles, which also differ in appearance from adult shell in their finer sculpture and more regular growth. The species has no resemblance to *C. minimum* (Hutt.), and its previous identification with Hutton's species must be attributed to the loss of his holotype. It is, however, very closely allied to the Recent *A. parkinsonianum* (Perry), the general style of shell and sculpture being the same in both. Perry's shell also has the narrow keel, elongated granules, and the 4 main cords, but differs in its shorter canal, almost complete absence of denticles on outer lip and columella, much finer and

closer spiral sculpture (main cords are less prominent and secondary cords are, though wider, lower and separated only by grooves), and coarser axial sculpture (all the early whorls have only 5 intervariceal ribs, and these decrease to 4, and then on the body-whorl only 3, very stout and distant nodules; these show the same abrupt change in size and level as in *A. maorium*). There can be little doubt as to the relationship of this shell to the Recent form on the one hand, and on the other to such Australian Tertiary forms as *C. radiale* (Tate), for which Cossmann proposed the genus *Austrotriton*. Kesteven (*Proc. Linn. Soc. N.S.W.*, vol. 27, 1902, p. 454) has commented on the similarity between *C. parkinsonianum* and this Australian group, and Iredale has on this account referred the Recent shell to *Austrotriton* (*Trans. N.Z. Inst.*, vol. 47, p. 459); the new species provides an interesting link between the two extremes in both its appearance and its geological age. The Australian ally of this shell seems to be *A. tortirostre* (Tate), but this is difficult to judge from figures alone. As in many other genera of the Cymatiidae, however, the limits of this genus seem ill defined, and there are several forms awaiting description which cannot be placed with nearly as much confidence as in the case of *A. maorium*. The author is of opinion that *Austrotriton neozelanica* M. & M. would be better placed in *Charonia*.

Var. insignitum n. var. (Plate 51, fig. 5.)

Differs from the species in having one sharp peripheral keel with a rounded base below, and much finer axial sculpture. Early whorls as in the species, but later ones with 9 axial ribs between varices, forming, and often reduced to, sharp nodules on keel. The difference in appearance results mainly from lack of nodules on second main cord. The change in size and level of nodules after a varix is much less marked in the variety, but the specimens are not adult. Several denticles on columella. The variety has a much neater appearance than the species.

Height, 22 mm.; diameter, 12·5 mm.; height of aperture, 11·5 mm. (type).

Type and one paratype, from Target Gully, in author's collection. Not yet found elsewhere.

Austrotriton (?) minimum (Hutt.). (Plate 18, fig. 5.)

The unique holotype of this species, previously supposed to be lost, has been discovered by Mr. Marwick, who kindly lent it to the author for examination. As Hutton's description is so slight, and so many wrong identifications have been made by subsequent workers, opportunity is here taken to redescribe the species. Holotype is in bad condition, lacks canal, protoconch, and much of the shell, and has aperture filled with matrix.

Shell not large, attenuated, aperture small in proportion to spire. About 5 whorls remain; the earlier ones are distinctly but bluntly angled slightly above middle; shoulder sloping at about 45°, thence much more steeply sloping inwards to suture below; on body-whorl this angle is almost obsolete, the whorl being subquadrately convex. Five or six intervariceal nodules per whorl, those just past a varix being considerably stronger and higher; on the lower whorls they project in a blunt point, but on early whorls are often elongated almost into backwardly-sloping axial ribs. The very faint lower keel on base bears only traces of nodules. Spiral cords cross whole surface, are quite prominent, flatly convex, and generally wider than interstices, but both vary considerably and irregularly.

On base an occasional cord seems to be stronger; on account of poor preservation the arrangement of these cannot be accurately described, but seems to be somewhat similar to that of *A. maorium*. No axial threads can be seen, and spirals are apparently not granulated. Five varices remain, about two-thirds of a whorl apart, rather narrow, hardly stouter than nodules, not prominent, and slightly sloping forwards. Sutures undulating, hardly discernible, but margined by a cord stouter than the others. Spire very high (1½–2 times height of aperture without canal), subturreted, giving shell a slender appearance, which in conjunction with its rather regular growth readily distinguishes it from any other New Zealand member of this genus. Aperture (filled with matrix) certainly small; outer lip reflected inwards past varix to form a sharp edge. Canal hidden and broken, but from small size of fracture-area it is evident that the amount lost is very slight, so that complete canal is probably short.

Height, 33 mm.; diameter, 16 mm.; height of aperture, 14 mm.

Type, from Broken River, Trelissick Basin (lower beds, Ototaran), in collection of New Zealand Geological Survey. No other specimens at present known.

The species seems to be characterized chiefly by its high spire; strong, regular, and smooth spiral threads; and rounded tubercles, some of which on early whorls are elongated slantwise, giving shell a *Perissoptera*-like appearance. Hutton at one time thought the species was identical with *C. tortirostre* (Tate), but Tate repudiated this identity (*Trans. Roy. Soc. S. Aust.*, vol. 10, p. 124), and did not compare it with any other species. In attenuated shape it resembles *C. protensum* (Tate), and if canal is long would be very like this species. It is also somewhat like *A. woodsi* (Tate), and this species also has a long canal. On the strength of this last resemblance Hutton's species is here placed in *Austrotriton*, but with much doubt, since the resemblance to the genotype, *A. radiale* (Tate), is but slight, though there do not seem to be essential generic differences. This is one of the "difficult" forms referred to in the remarks on *A. maorium*. It is in some respects like a *Charonia*, but the character of the varices seems to forbid placing it in that genus.

Austrotriton cyphoides n. sp. (Plate 51, figs. 3*a*, 3*b*.)

Shell small, shortly fusiform, with prominent peripheral carina and nodules. Protoconch globular, slightly asymmetrical, of about 4 smooth convex whorls, but tip is lost. Four whorls succeed this, strongly carinated below middle; shoulder straight, slope almost about 40°, thence slanting slightly in below carina to suture below; base rapidly contracted into broad, slightly twisted beak; varices at a little less than every three-quarters of a whorl, very low and inconspicuous, broadly convex towards aperture, but angled and concave away from it. Five strong peripheral nodules between varices, sharp along keel but blunt vertically; they extend to suture below on spire-whorls but hardly at all on shoulder; on body-whorl they vanish just below periphery, their termination being indicated by a spiral cord slightly more prominent than the others; no anterior keel apart from this. Whole surface bears slightly undulating, narrow, flattish spiral cords, interstices much wider on shoulder and base but narrower on keel; rarely one interstitial riblet on base. Extremely dense and fine axial threads (not visible except under good lens) run over whole surface, producing slightly roughened effect. Aperture broken, but evidently lirate-dentate within, inner lip spread thinly over columella,

bearing distinct parietal plait, but only very indistinct traces of tuberoles below.

Height, 17 mm.; diameter, 10 mm.

Holotype (unique), from Kakanui Beach (tuffs below the limestone), in author's collection.

This belongs to a group of gibbous, carinate species, typified in the Australian Tertiaries by such forms as *A. radiale* (Tate), *A. gibbum* (Tate), and *A. textile* (Tate). It is closest to *A. cyphum* (Tate), the two being very nearly related. The new shell seems to differ only in its blunter, less vertically compressed nodules and slightly different spirals. In the absence of authentic specimens of the Australian species for comparison, the author prefers to consider it and the New Zealand shell as nearly related rather than identical.

Cymatium revolutum n. sp. (Plate 51, figs. 2*a*, 2*b*.)

Shell rather small, ovate; spire very little distorted by varices, which occur at intervals of less than three-quarters of a whorl. Whorls regularly rounded, no prominent carinae or nodules. Apex, canal, and outer lip missing in all specimens About 14 narrowly convex spiral cords on body-whorl, 5 or 6 on penultimate, interstices 2–3 times their width, with 1–4 very fine interstitial riblets; less prominent vertical axial ribs (12-15 between varices) cancellate the spirals, raised at intersections into small sharp tubercles. Extremely fine and close secondary axial sculpture reticulates interstitial spiral riblets. Varices not very much wider or more prominent than axial ribs, but less tuberculose, and slant in different direction.

Height (estimated), 16 mm ; diameter, 9 mm. (type juvenile).

The largest paratype, of which only three anterior whorls remain, is 17 mm. diameter and would reach over 30 mm. in height.

Types (two) and paratypes (two), from Kakanui Beach (tuffs below the limestone), in author's collection.

The species shows some analogy with *C. gemmulatum* (Tate) from Muddy Creek, from which it differs in its less turriculate spire, secondary sculpture, and relatively fewer varices. Another close ally seems to be *Ficus transennus* Sut. This is not a *Ficus*, but very probably a *Cymatium*, of the "*revolutum*" group; if so, it differs from that species in much lower spire and stronger axials in comparison with the spirals. It is also from a higher horizon, for it may be noted that the "*Turbo marshalli* fauna" of the Kakanui tuffs is identical with that from the true Waiarekan tuffs a significant fact, which will be discussed on another occasion.

Cymatium marwicki n. sp. (Plate 51, figs. 1*a*, 1*b*.)

Shell rather small, fusiform, very little distorted by varices, which occur at intervals of almost three-quarters of a whorl; 3½ post-embryonic whorls, regularly rounded, the 3 peripheral carinae only slightly interrupting their convex outlines. Protoconch apparently large, initial whorls missing, final volution with 4 faint ridges, the upper and lower much more prominent, a distinct break (but no varix) marks it off from true sculpture. This consists on early whorls of 6 low, subequidistant, spiral keels, the lowest close to, the uppermost margining the suture. On later whorls the three upper cords always remain much weaker than the others, of which peripheral one becomes strongest, those below on body-whorl gradually falling away in strength. Six cords below peripheral one present on body-whorl down to end of outer-lip varix. below this are about 10 more on neck of canal, stronger and weaker alternating. Interstices between the three main cords occupied

by 6 subequal spiral threads with narrow spaces between, but between lower cords of body-whorl central thread is more prominent, with one or two others between it and the strong cords; these secondary spirals are often minutely catenate. Axial sculpture represented on early whorls by 9 flexuous ribs between varices; they are considerably narrower than their interstices, and points of intersection with spiral cords are raised into nodules. On later whorls axials become irregular, and break up or become obsolete on reaching main spiral cord. Nodules, however, become stronger, so that all the spiral cords on body-whorl (but more especially the three peripheral ones) are strongly bossed with bluntly-conical warts. There are more of these on the second peripheral cord than on the main one, and still more on third and those below. Traces of axial ribbing remain even near canal. Secondary spiral threads not nodulous but finely reticulated by secondary axial threads subequal to spirals and with linear interstices. Whole of sculpture except nodules extends over varices, which form regular, fairly high, convex ridges, running almost parallel to axials. Outer lip with sharp raised edge inside varix, strongly dentate by 9 teeth within. Columella straight, with 5 plaits on lower part and a few rugosities above these. Parietal wall shows basal sculpture plainly, and bears strong plait near outer lip. Canal about half length of aperture, bent to left and slightly backwards Spire a little less in height than aperture with canal. Sutures not strong, almost straight.

Height, 25 mm; diameter, 13 mm.; height of aperture with canal, 15 mm.

Type (unique), from McCullough's Bridge, Waihao (Waiarekan) in collection of New Zealand Geological Survey, kindly lent for examination and description through Mr. Marwick.

Closely related to the preceding species, differing in its varices (which are not so flattened, more prominent, slightly wider apart, and without antecurrent lip at suture) and in degree of sculpture, axials being less numerous, the nodules a little blunter but much stronger, and peripheral ribs much more prominent than the others. Secondary sculpture, too, is a little different, both axials and spirals being much wider than their interstices in the Waihao shell, but much narrower in *C. revolutum*. The next species is another ally.

Cymatium kaiparaense n. sp. (Plate 48, fig. 8.)

This is so evidently descended from the previous species and so like it in most respects that a full description is unnecessary, the general style of shell and sculpture being the same in both. It differs in having carinate, not convex, whorls, even at an early stage, due to stronger peripheral and weaker shoulder spirals. In this it is intermediate between *C. marwicki* and the species next described. Secondary sculpture more like that of *C. revolutum*, axial and spiral threads being much narrower than their interstices. The most striking difference, however, is that varices are only a little over half a whorl apart instead of three-quarters whorl– *i.e.*, on successive whorls the varices are nearly in line, while in *C. marwicki* and the next species varices occur nearly in line only on alternate whorls. Although there are the same number of nodules in both species, they do not appear any closer on *C. kaiparaense*, but rather the reverse, due to the fact that they are less elongated and more prickly and are not appreciably more numerous on spiral below periphery.

Satisfactory dimensions cannot be given, on account of the fractured state of the type.

Type (unique), from Pakaurangi Point, Kaipara Harbour (Ototaran or Hutchinsonian), in author's collection. The peculiarly close varices make the species somewhat resemble an *Argobuccinum*, but it is so evidently congeneric with the species described immediately before and after it that it is best referable to *Cymatium*.

Cymatium sculpturatum n. sp. (Plate 48, fig. 7.)

Shell of moderate size, turriculate, with several keels and irregular warty tubercles. Protoconch of 3 globose whorls. Four whorls follow, descending rather rapidly, so that spire is considerably elevated (about $1\frac{1}{4}$ times aperture without canal). Whorls quadrately convex, medially keeled, shoulder sloping at about 45°, thence descending vertically to lower suture, between which and peripheral keel is another strong keel. Below these two main keels there is, on body-whorl, a third keel, and below this about 4 strong spiral cords, all more or less prominently nodulose, the shell appearing to bear rather irregularly-dispersed and bluntly-pointed knobs. This irregular appearance is due to two factors the increase in size of tubercles on peripheral keel as a varix is approached, and simultaneous decrease in size of tubercles on all other ribs, and to the progressive increase in number of tubercles on lower keels. On body-whorl of type, between the last varices, there are 7 nodules on peripheral keel (6 on some of the paratypes), then in succession 9, 11, and 13 on keels below it; increase most rapid near aperture. Irregularly-rounded undulating axial ribs extend from suture towards peripheral nodules, but they are not contiguous with them, and slant in various directions. These ribs render nodulose two weaker spirals intercalated at even distances between peripheral keel and suture above. Besides this characteristic primary sculpture of tuberculate keels there is an even more characteristic secondary sculpture. Interstices between the keels contain about 6 flattish and not prominent spiral riblets, distinctly and beautifully catenate, and alternately stronger and weaker, interstices linear. Crossing these in turn are numerous hair-like axials varying considerably in direction. This secondary sculpture becomes distorted and largely erased on nodules. Outer lip and most of canal missing on all specimens. Varices at a little less than three-quarters of a whorl, Epitoniform, convex, rather high and compressed, crossed by all the spiral and axial sculpture, but without nodules. Columella vertical, with two or three Marginelliform plaits; a few close, strong, elevated plaits on parietal wall. Outer lip evidently strongly lirate-tuberculate inside.

Height (without canal), 25 mm.; diameter, 17 mm.; height of aperture, 11 mm. (holotype). Height (without canal), 37 mm. (?); diameter, 19 mm.; height of aperture, 16 mm. (?) (largest paratype).

Holotype and seven paratypes, from Kakanui Beach (tuffs below the limestone), in author's collection.

The last four species and *C. transennum* (Sut.) form a rather compact group, distinguished by regular growth, prominent and prickly (or tubercular) spiral sculpture of two stronger peripheral ribs and two weaker ones above them on shoulder with regularly diminishing spirals on base, and reticulate secondary sculpture, the spiral part of which is often catenate. The last species represents the extreme development of the warty prickles, and these give it a superficial resemblance to *Austrotriton maorium*, from which, however, it differs markedly in all details. The Australian representative of this group and of this species, and *C. kaiparaense* especially, seems to be *C. intercostale* (Tate). It has the same regular, staged, and prickly aspect as *C. sculpturatum*, and it may be noted that Tate

comments on the short distance the varices are apart. as has already been done here in the case of *C. kaiparaense.* Tate also notes the "obliquely costated posterior slope": this is also a striking feature in the two species last described.

C. revolutum and *C. transennum* bear a resemblance to *Plesiotriton dennanti* Tate, the type of the genus *Semitriton* Cossmann, but as none of the specimens show the characteristic columellar plaits of that species they are not here referred to that genus.

Cymatium octoserratum n. sp. (Plate 48, figs. 6*a*, 6*b*.)

Shell very small, fusiform, whorls slightly askew but growth otherwise regular, canal short. Protoconch as in *Austrotriton maorium*, of about 4 regularly-convex whorls, conical and symmetrical, with 3 faint equidistant keels indicated at extremity, the true sculpture beginning abruptly and with a varix. Four adult whorls, lightly carinate below middle, but hardly interrupting the straight spire-outlines. Spire higher than aperture with canal. Spire-whorls with regular spiral cords, 5 on shoulder, 4 stronger ones below, strongest being on keel. On body-whorl every third cord below keel is much stronger, but after fourth strong cord (including peripheral one) spirals alternately strong and weak extend over canal. All spirals finely granular, the granules being distant, blunt, and rounded. Eight axial ribs between every pair of varices, thin on shoulder, rapidly swelling out to greatest prominence on keel, where they form small but fairly sharp tubercles, strong between first and second main cords, almost at once dying away below this, but their continuation marked by sharp prickles that serrate all main cords. Extremely dense and fine hair-like axial threads form the only secondary sculpture. Varices at about three-fifths of a whorl, not high, inconspicuous in front, deeply incised and rather abrupt behind, crossed by all sculpture except nodules, parallel to axial ribs. Aperture subrhomboidal, small, produced into a very short canal (about one-third of aperture in length) turned strongly to left and backwards. Outer lip with sharp edge past varix, thickened and with 5 strong teeth within. Columella lightly concave, with 2 denticles anteriorly. Inner lip spreading out to thin sharp edge past columella and on parietal wall, with narrow plait some distance from outer lip. A tiny triangular umbilical chink between strong fasciole and inner lip.

Height, 13 mm.; diameter. 7 mm.; height of aperture with canal, 6 mm. (type).

Type and eight others, from Target Gully, in author's collection. Also from Ardgowan and Awamoa (beach-boulders).

This species is separable from juveniles of *A. maorium*, occurring at the same locality, by its much shorter canal, higher spire, less gibbous growth, and much finer axial sculpture. It does not seem closely related to any other New Zealand species, but seems to be without doubt a member of the Australian "*quoyi*" group, being apparently closest to that species itself and *C. oligostirum* (Tate). One of the paratypes has 10 intervariceal costae, and this brings it still closer to the Australian shells.

Cymatium n. sp.

In the writer's collection is a fragment of a large new species from Clifden, Southland (band 8A—Awamoan ?). It seems to be related to *C. spengleri* (Chemnitz) and also to *C. sculpturatum* n. sp., but since the surface of the shell is everywhere abraded, so that the details of sculpture are obscured, it is best left undescribed.

Cymatium decagonium n. sp. (Plate 48, fig. 4.)

Shell small, of somewhat squat appearance, with prominent spiral cords and distant axial ribs. Apex worn. Spire subequal in height to aperture with canal. About 3 post-embryonic whorls, obtusely angled submedially, each with 2 strong spiral cords on lower half and 2 much weaker ones on wide and sloping infrasutural space. Interstices much wider than cords, bearing 1–3 very fine and distant spiral threads. On body-whorl this sculpture is continued to canal, there being 3 main peripheral cords (the lowest emerging from suture) and 4 slightly weaker ones down to end of outer-lip varix, all equidistant, and below them further cords, alternately fairly strong and weak. Seven intervariceal axial ribs on the average, but only 6 on body-whorl (almost obsolete below third carina) and 9 on antepenultimate whorl. Ribs almost straight, a little sharp and very thin, interstices being many times their width and bearing rather prominent growth-striae; secondary axial sculpture only faintly indicated. Axial ribs bear at points of intersection with the 3 main cords regular and sharp but hardly tubercular serrations, so that an apical view of the shell shows the logarithmic spiral of the whorls neatly divided into about 10 angles per whorl; otherwise spirals and axials have a smooth appearance. Varices at a little less than three-quarters of a whorl, almost parallel to axial ribs, rather high, narrowly convex, and excavated behind between cords. Outer lip with sharp raised edge past varix, thickened and with 7 strong and subequidistant teeth within. Columella lightly concave, with 4 small plaits anteriorly. Tubercle on parietal wall very weak, but basal sculpture plainly shown. Canal very short (but seems to be broken and worn), turned slightly to left and backwards.

Height, 21 mm.; diameter, 13 mm.; height of aperture with canal, 12 mm.

Type (unique), from Waihao Downs, in Mr. R. S. Allan's collection.

This puzzling form does not compare well with any other New Zealand fossil species. It does not seem to be an *Austrotriton*; the 2 strong keels on spire-whorls are not shown by *A. maorium* or other New Zealand species of this genus, but are more reminiscent of the *C. sculpturatum* group. From these, however, it is at once sundered by the absence of prickly knobs, the appearance of the serrations being distinctive. In many respects it resembles the Recent *C. exaratum* (Reeve), axial and spiral ribs being nearly the same in number, appearance, and arrangement, except that main cord, and therefore peripheral keel, on *C. exaratum* is considerably higher up, so that the spire is much more staged. There is the same number of internal teeth on outer lip, and plaits on columella, and the same very weak parietal plait. Whether this resemblance is superficial or ancestral cannot be determined without study of intermediate forms. Neither *C. exaratum* nor any allied form has yet been found fossil in New Zealand.

Charonia clifdenensis n. sp. (Plate 48, figs. 9*a*, 9*b*, 9*c*.)

Shell small for the genus, fusiform, of rather distorted growth, thick and solid. Protoconch of 3 very convex, smooth whorls, the apical ones rather depressed so that shape is not so regular and conic as in *Austrotriton maorium*, &c.; separated from adult sculpture by slight varix. Adult whorls 7, the earlier ones faintly shouldered at lower third by a row of vertically-elongated nodules, 5 or 6 between varices; on lower whorls 3 or 4 nodules past each varix become very strong and sometimes make penultimate whorl biangulate just above suture, but the other nodules

almost disappear so that anterior half of intervariceal areas is lightly convex and smooth except for spiral sculpture. This forms regular, distant, fine and granulate cords over the whole surface, a stronger cord being generally followed by 1–3 weaker threadlets; the number of main cords is difficult to estimate, but there are about 10 on shoulder and below periphery on body-whorl, and 5 or 6 stronger, thicker, and closer ones on neck of canal; spirals are more crowded on upper half of whorl, and are faintly studded with minute blunt and low tubercles, much more than their own width apart. Secondary sculpture characteristic, most prominent near periphery, surface being elaborately cut up by wire-netting-like grooves into a shagreened aspect like a reptilian skin. Apart from more or less distinct growth-lines, greater part of whorl has no axial sculpture, nodules being confined to periphery. Varices not quite in line on alternate whorls, lower ones being somewhat behind upper; they are thick, low, and wide, pressed close to whorl, very gently sloping behind, descending more steeply in front to curved, sharp edge, hardly separated from level of whorl. Where surface of shell is best preserved the combined forms of sculpture give it a satin-like texture and gloss; outer and especially inner lip highly polished. Spire considerably higher than aperture with canal. Suture impressed, very uneven. Aperture relatively rather small, with very thick walls, slightly oblique, ovate, channelled above, produced below into short narrow, but strong recurved canal. Outer lip expanded, especially below, 7 or 8 heavy denticles within, lowest two adjacent; columella much excavated, with about 7 thick ridges extending over most of its length in juvenile shells, but with 4 or 5 thick, low, and close elongate tubercles at base in adults. Inner lip extending some distance past columella with definite boundary, but forming no false umbilicus; very heavy parietal tubercle at junction with outer lip, but otherwise no plaits or wrinkles.

Height, 54 mm.; diameter, 25 mm.; height of aperture with canal, 25 mm. (type). Corresponding dimensions of a paratype, 53 mm., 23 mm., 23 mm.

Type, and one adult and two juvenile paratypes, from Clifden, Southland (band 6A –Ototaran ?), in author's collection.

Closely related to *C. neozelanica* (M. & M.) from Target Gully, but easily distinguished by its more slender shape (diameter less than half height instead of more), relatively much smaller aperture, and, judging from the figure, finer spirals and granules. Except for these points the diagnosis of *A. neozelanica* given by Marshall and Murdoch exactly fits *A. clifdenesis*, so that the Target Gully shell is evidently a descendant of the new species. That these shells belong to *Charonia* and not to *Austrotriton* is shown best by their low and wide adpressed varices and characteristic columellar plication when juvenile, the numerous horizontal plaits over almost all the columella being well shown by juveniles of *C. lampas* (L.). Distorted growth and granulation of the spirals are characters not restricted to *Austrotriton*, and, though it is almost impossible to draw the line of separation between various genera of this difficult family, the two shells here treated are far more in accord with *Charonia* than with *Cymatium* (s. str.) or *Austrotriton*. *C. ovoidea* (Tate), the Australian Tertiary member of this genus, has little resemblance to the New Zealand species.

Two other fossil species of *Cymatium* have been described from New Zealand, and, to complete this account of the family, notes on these and on some Recent species are appended, and, finally, a key to all our species is given.

Cymatium suteri M. & M.

The author is of opinion that this species is a *Xymene*, and so should not be included in the Cymatiidae.

Cymatium pahiense M. & M.

This is a peculiar species, and, as noted by the authors, is unsatisfactorily placed in *Cymatium*. If it belongs to this family at all, the strong posterior notch would seem to bring it nearer to the Bursidae, but the general appearance of the shell is somewhat like that of a Cassid. At present its position must be regarded as quite uncertain.

Charonia lampas (L.).

Septa rubicunda Perry: Suter, *Man. N.Z. Moll.*, p. 303.

Charonia lampas var. **euclia** Hedley.

C. nodifera var. *euclia* Hedley, *Biol. Res.* "*Endeavour*," vol. 2, 1914, p. 65.

Iredale (*Trans. N.Z. Inst.*, vol. 47 p. 458, 1915) has united the species *rubicunda*, *nodifera*, and *sauliae*, and gives the oldest name as *C. lampas* (L.). The author has obtained (by trawling outside Otago Heads in 22 fathoms) one fine adult shell that agrees almost exactly with Hedley's figure and description of the var. *euclia*. All the Australian specimens were dredged in very much deeper water.

Argobuccinum tumidum (Dkr.).

A. argus (Gmel.): Suter, *Man. N.Z. Moll.*, p. 309. (See Hedley, *Proc. Linn. Soc. N.S.W.*, vol. 38, p 297, 1913.)

Mayena australasia (Perry).

Argobuccinum australasia Suter, *Man. N.Z. Moll.*, p. 310.

Iredale (*Proc. Mal. Soc.*, vol. 12, p. 324, 1917) has proposed the generic name *Mayena* for this species and *gemmifera* (Euthyme). In the same place, however, he noted that Bartsch had classed the South African species in *Eugyrina* Dall. Hedley (*Proc. Roy. Soc. N.S.W.*, vol. 51, p. 66) has reduced *Mayena* to a synonym of *Eugyrina*; but May (*Check-list of the Mollusca of Tasmania*, pp. 64 65, 1921) has employed both genera, retaining *Mayena* for *australasia*, a course which is adopted here. Suter (*Alph. List N.Z. Tert. Moll.*, 1918) records only this species and *C. spengleri* of our Recent species as fossil in the New Zealand Tertiary.

Priene retiolum Hedley (*Biol. Res.* "*Endeavour*," vol. 2, p. 73, 1914).

This rare deep-water species should be admitted to the New Zealand Recent fauna, one broken specimen having been found by the author at Taieri Beach, South Island, washed up on the rocks. It presents an appearance so dissimilar to *Argobuccinum tumidum* (Dkr.), the genotype of *Argobuccinum*, that *Priene* is here given generic rank.

Cymatium parthenopeum (von Salis).

Septa costata (Born): Suter, *Man. N.Z. Moll.*, p. 305.

Iredale (*Trans. N.Z. Inst.*, vol. 47, p. 459, 1915) has advised use of the above name for this shell, and has placed it under *Cymatium* in the subgenus *Monoplex*, referring *C. exaratum* (Reeve) and *C. spengleri* (Perry)

to the subgenus *Cabestana*. There does not, however, seem to be any similarity between the two latter shells, but *C. exaratum*, apart from its much smaller size, seems quite close in all details to *C. parthenopeum*, and is here grouped with it. *C. spengleri* does not closely resemble other New Zealand species. No sectional names are used in this *résumé* of the family; of the six genera admitted, *Cymatium* and *Austrotriton* both need subdivision, but it is so difficult to place many Tritons in even a suitable genus, and the relationships of some of the New Zealand species are so obscure, that no sectional division has here been attempted. One cannot help recalling Kesteven's argument (*Proc. Linn. Soc. N.S.W.*, vol. 27. pp. 443–83, 1902) that no satisfactory grouping of the Tritons can be made. In the key appended, the species *Austrotriton maorium* var. *insignitum* and *Cymatium decagonium* are out of place, but the others are grouped, according to their relationships into ten more or less distinct groups.

KEY TO THE NEW ZEALAND CYMATIIDAE.

Shell with 3 varices in 2 whorls.

(A.) Shell of distorted growth, due to flattening before a varix and gibbous inflation after it (often inconspicuous in juveniles).

(*a.*) Shell usually rather squat; keel sharp or blunt, tending to prominence with age; of very distorted and gibbous appearance when adult; varices narrow, high, and prominent, even on early whorls, steeply descending on either side; canal usually long .. .. AUSTROTRITON (*a*).

(*b.*) Shell more slender and tapering; keel tending to disappear with age; of less distorted, more graceful appearance; varices broad, low, and often inconspicuous on early whorls, of much gentler incline on either side, especially behind; canal short .. CHARONIA (*b*).

(B.) Shell of almost regular growth, the sculpture being hardly interrupted by the varices, which are like those of *Austrotriton* .. .. CYMATIUM (*c*).

Shell with 4 varices in 2 whorls.

(C.) Shell solid.

(*d.*) Shape fusiform; whorls shouldered, with a strongly nodose carina, varices elevated .. .. MAYENA (*d*).

(*e.*) Shape oval; whorls convex, spirally subnodulosely striated; varices flattened .. .. .. ARGOBUCCINUM (*e*).

Shell with irregular varices, 2, 1, or none to a whorl.

(D.) Shell thin, ovately fusiform; whorls convex, surface neatly reticulated by thin and subequal spirals and axials; varices convex but low .. .. .. PRIENE (*f*).

(*a.*) (Group 1.) Periphery of body-whorl angled.

(i.) No other keels below this; 5 intervariceal nodules .. .. *A. cyphoides.*

(ii.) Three weaker keels below this; 9 intervariceal nodules .. .. *A. insignitum.*

(Group 2.) Periphery of body-whorl subquadrate.

(i.) Shell slender; spire much higher than aperture and canal .. .. *A.* (?) *minimum.*

(ii.) Shell squat; spire subequal to aperture and canal.

1. Aperture almost smooth within; 3 nodules between last two varices .. *A. parkinsonianum.*

2. Aperture strongly denticulate on columella and inner lip; 5 nodules between last two varices .. .. *A. maorium.*

(*b.*) (Group 3.)

(i.) Adult shell very large, with whole of columella and inner lip covered with strong irregular plaits and wrinkles, except for a short distance near outer lip, which is thin and without prominent teeth, early whorls with 4 strong and equidistant tuberculate cords .. *C. tritonis.*

(ii.) Adult shell very large, with the long and narrow parietal plait separated by a smooth space from the columellar plaits, and distant from the outer lip, which is thick, with an internal groove behind it; early whorls with two rows of nodules on the lower half.

1. .. .. *C. lampas.*
2. Shell larger, more slender, and with smaller, closer, and more prominent nodules .. .. var. *euclia.*

(iii.) Adult shell small, with the thick parietal tubercle separated by a considerable smooth area from the columellar plaits and joined to the outer lip, which is thickened, without an internal groove, early whorls with one row of nodules above the suture.

1. Aperture large, width more than half the height .. .. *C. neozelanica.*
2. Aperture smaller, width less than half the height .. .. .. *C. clifdenensis.*

(*c.*) (Group 4.) Shell very small (under 15 mm.), with a peripheral keel and 3 more below it; 8–10 short and prickly axial ribs between varices .. .. *C. octoserratum.*

(Group 5.) Shell with only 2 varices; the upper whorls disc-like (owing to the flat shoulder) and with 2 strong keels; body-whorl with 6 strong cords.

(i.) Shell small; 4 strong axial ribs between varices *C. exaratum.*

(ii.) Shell large; no distinct axial ribs, but about 10 swellings on keels between varices .. *C. parthenopeum.*

(Group 6.) Shell large; sculpture crossed by prominent axial cordlets; aperture large and expanded; outer lip frilled and with a wide sunken, internal groove, crossed by strong, paired ribs .. .. .. *C. spengleri.*

(Group 7.) Shell small; spire-whorls with 2 stronger ribs below, 2 weaker ones above.

(i.) Whorls convex.

1. Surface reticulated by thin and subequal spirals and axials.
   - (i.) Spire low, axials and spirals subequal .. .. .. *C. transennum.*
   - (ii.) Spire higher, axials weaker than spirals .. .. .. *C. revolutum.*
2. Main spirals with about 9 strong, prickly tubercles between varices .. .. *C. marwicki.*

(ii.) Whorls angled.

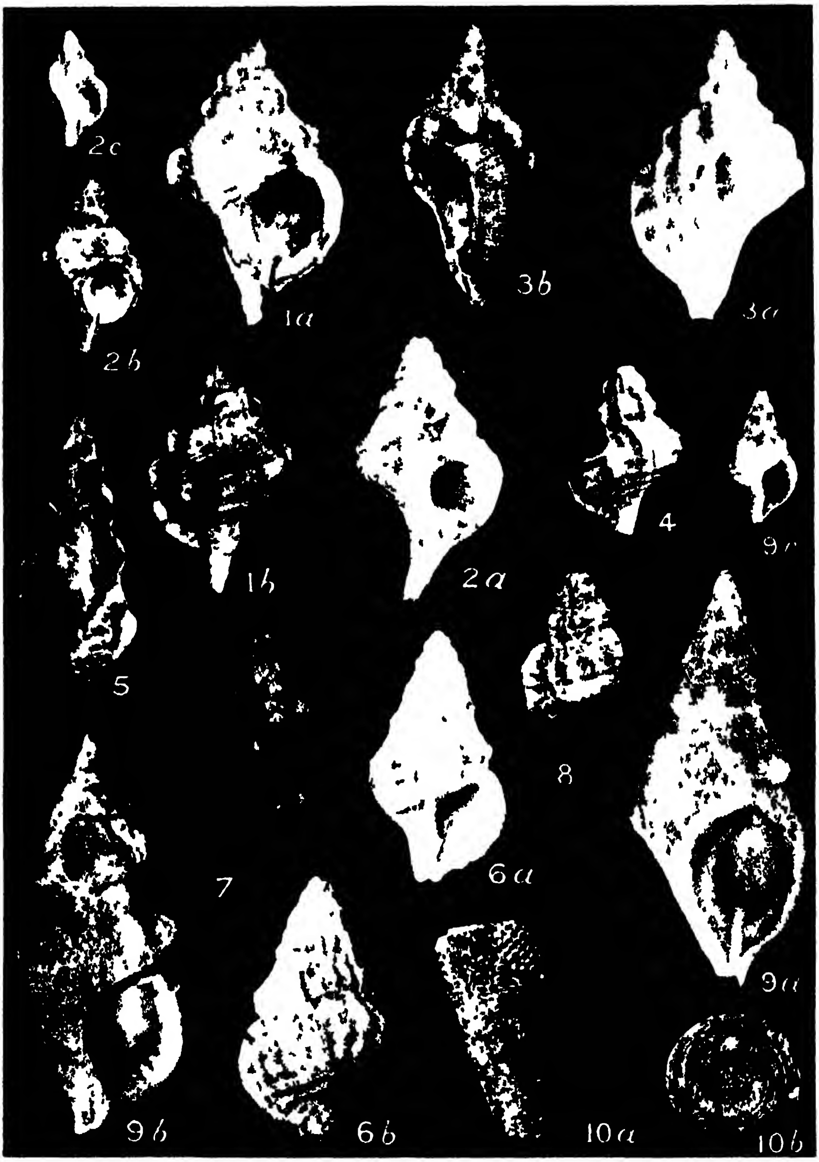
1. Varices almost in line on successive whorls; main cords and tubercles not very strong .. .. .. *C. kaiparaense.*
2. Varices in line on alternate whorls; main cords and tubercles very strong; sculpture warty .. .. .. *C. sculpturatum.*
3. Varices nowhere in line; main cords strong, but without prickles; distant narrow axial ribs .. .. .. *C. decagonium.*

(*d.*) .. .. *M. australasia.*

(*e.*) .. .. *A. tumidum.*

(*f.*) .. .. *P. retiolum.*

(*Inc. sedis*) .. .. *C. pahiense.*



Figs 1a, 1b Austrotriton maorium n sp. Holotype, Target Gully.
Figs 2a, 2b, 2c — Austrotriton maorium n. sp. Paratypes—(a) Target Gully; (b) Otiake, (c) Clifden: juvenile.
Figs. 3a, 3b — Austrotriton maorium n. sp. Paratypes, Clifden: adult.
Fig 4. —Cymatium decagonium. Holotype
Fig. 5 — Austrotriton (?) minimum (Hutt.) Holotype
Figs. 6a, 6b.—Cymatium octoserratum n sp Holotype
Fig 7.—Cymatium sculpturatum n. sp. Holotype.
Fig. 8 —Cymatium kaiparaense n. sp Holotype
Figs 9a, 9b, 9c. Charonia clifdenensis n. sp. (a) Holotype; (b) and (c) paratypes; adult and juvenile
Figs. 10a, 10b.—Conus triangularis n. sp. Holotype.

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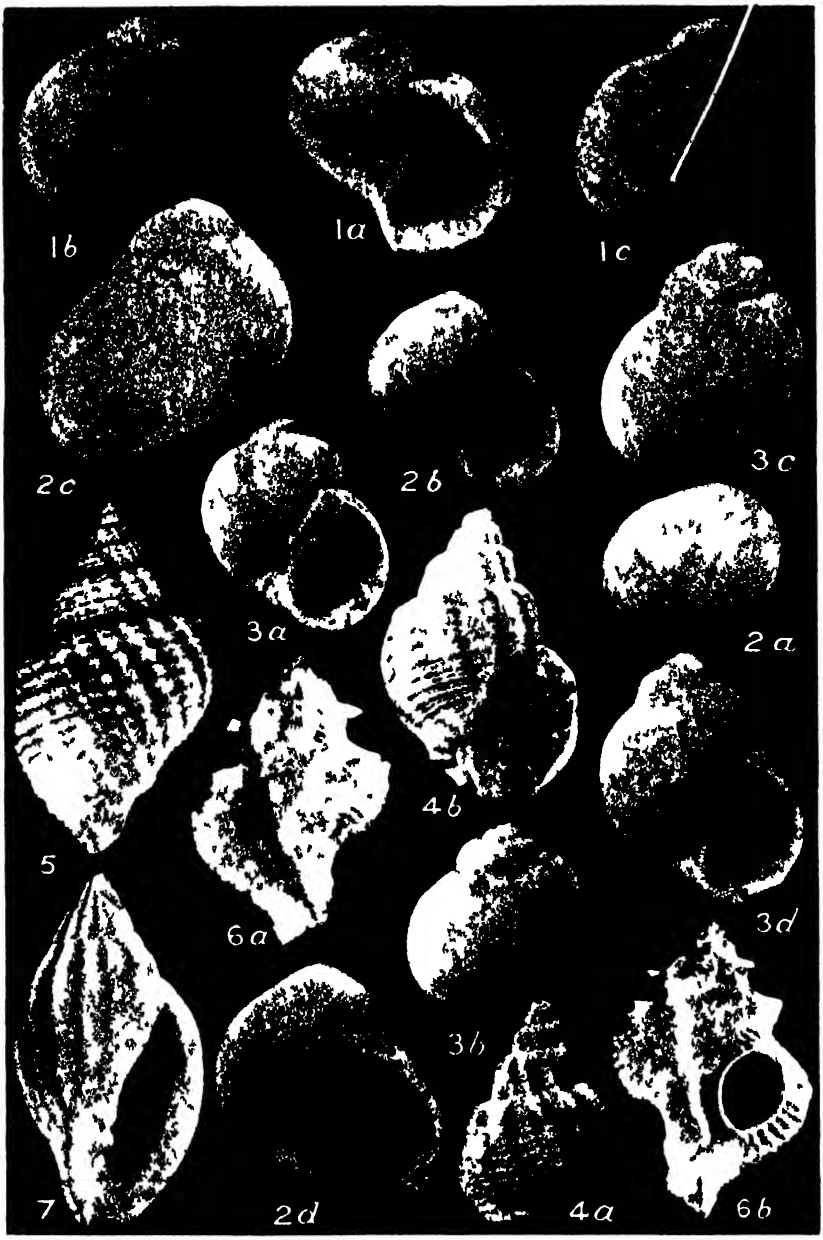

FIGS. 1a, 1b, 1c.—*Natica consortis* n. sp. (a) Holotype, Pukeuri; (b) paratype, Pukeuri; (c) paratype, Rifle Butts.
FIGS. 2a, 2b, 2c, 2d.—*Natica notocenica* n. sp. (a) Holotype, Awamoa; (b), (c), and (d) paratypes, Pukeuri.
FIGS. 3a, 3b, 3c, 3d.—*Polinices pseudovitreus* n. sp. (a) Holotype; (b), (c), and (d) paratypes.
FIGS. 4a, 4b.—*Trigonostoma waikaiaensis* n. sp. Holotype.
FIG. 5.—*Trigonostoma christiei* n. sp. Holotype.
FIGS. 6a, 6b.—*Typhis francescae* n. sp. Holotype.
FIG. 7.—*Lyria zelandica* n. sp. Holotype.

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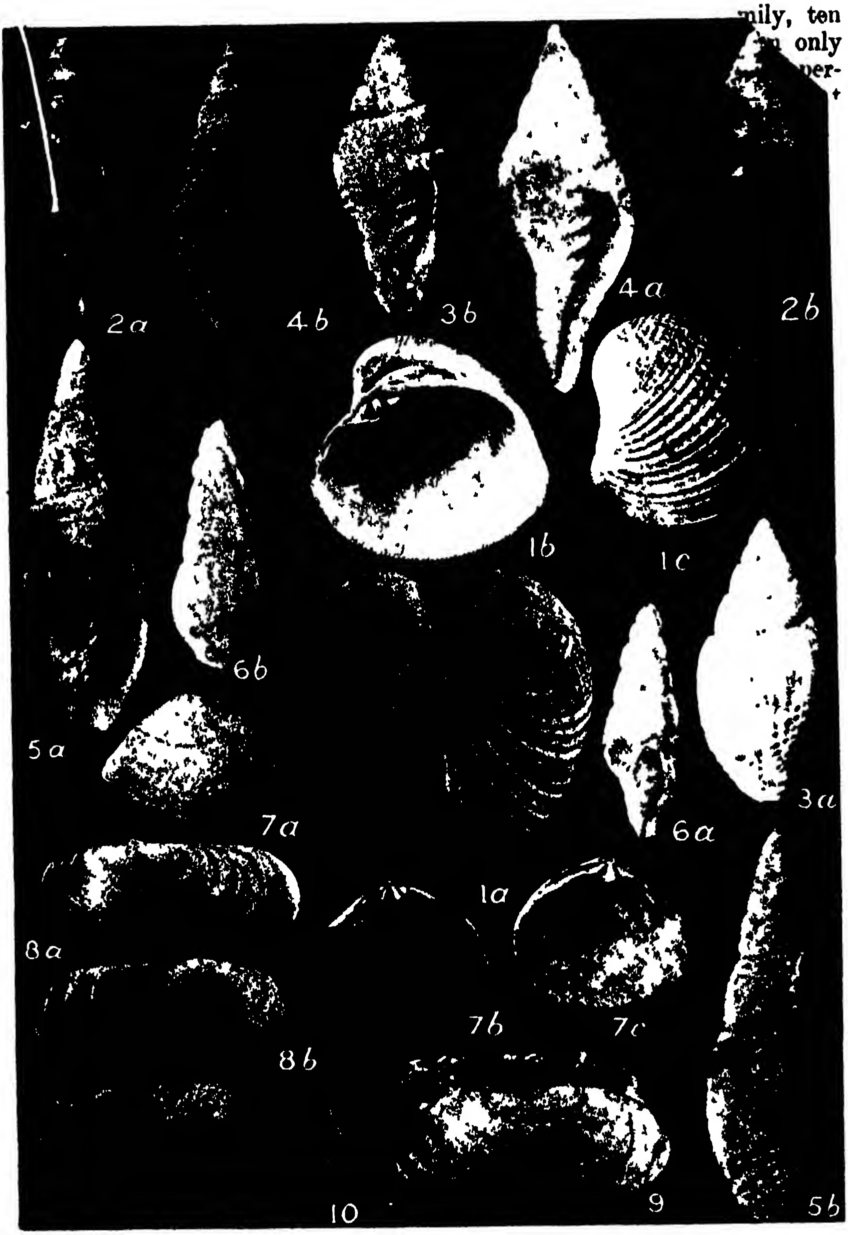
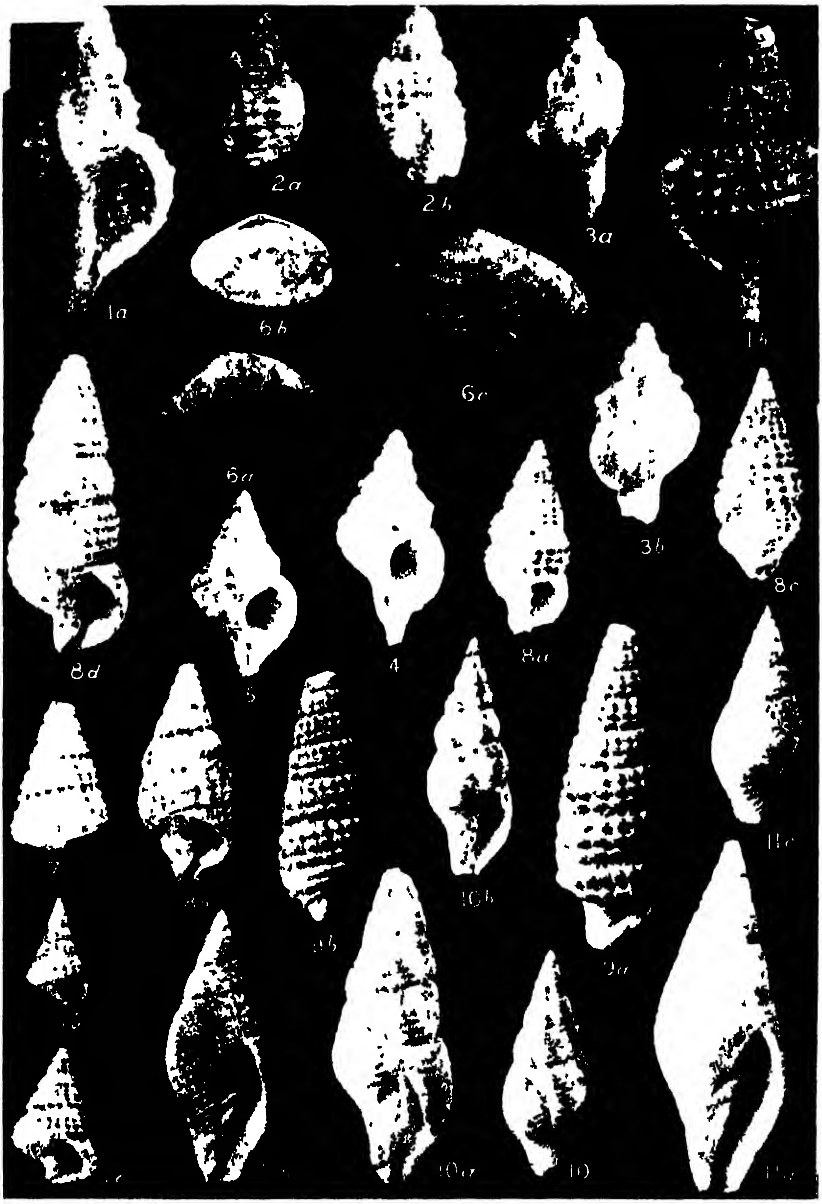


FIGS. 1a, 1b, 1c.—*Chione crassitesta* n. sp Holotype.
FIGS. 2a, 2b.—*Conomitra inconspicua* (Hutt.). Topotype.
FIGS. 3a, 3b.—*Conomitra othoniana* n. sp. Holotype.
FIGS. 4a, 4b.—*Mitra (Cancilla) armorica* Sut. Otiake specimen.
FIGS. 5a, 5b.—*Mitra elatior* n. sp. Holotype.
FIGS. 6a, 6b.—*Uromitra etremoides* n. sp. Holotype.
FIGS. 7a, 7b, 7c.—*Barytellina anomalodonta* n. sp. Types.
FIGS. 8a, 8b.—*Solecurtus bensoni* n. sp. Holotype.
FIG. 9.—*Solecurtus evolutus* n. sp. Holotype.
FIG. 10.—*Solecurtus chattonensis* n. sp. Holotype.



Figs. 1a, 1b.—*Cymatium marwicki* n. sp. Holotype.
Figs. 2a, 2b. *Cymatium revolutum* n. sp. Holotype.
Figs. 3a, 3b.—*Austrotriton cyphoides* n. sp. Holotype.
Fig. 4. *Austrotriton maorium* n. sp. Paratype, Target Gully.
Fig. 5.—*Austrotriton maorium* var. *insignitum* n. var. Holotype.
Figs. 6a, 6b, 6c.—*Macoma robini* n. sp. (*a*) Holotype; (*b*) and (*c*) paratypes.
Figs. 7a, 7b, 7c.—*Ataxocerithium pyramidale* n. sp. (*a*) Holotype; (*b*) and (*c*) paratypes.
Figs. 8a, 8b, 8c, 8d.—*Ataxocerithium nodicingulatum* n. sp. (*a*) Holotype; (*b*), (*c*), and (*d*) paratypes.
Figs. 9a, 9b.—*Ataxocerithium suteri* Marwick. Petane specimens.
Figs. 10a, 10b, 10c.—*Uromitra etremoides* n. sp. Paratypes.
Figs. 11a, 11b, 11c.—*Mitra eusulcata* n. sp. (*a*) Holotype; (*b*) and (*c*) paratype.

Of the above twenty-four New Zealand members of this family, ten are Recent species, and all these occur also in Australia. Of them only two are recorded as fossil in New Zealand, and these only from the uppermost Pliocene; one of them (*Mayena australasia*) apparently does not occur fossil in Australia, but the other (*Cymatium spengleri*) is recorded from the later Pliocene (Limestone Creek, Glenelg River). Of the remaining fourteen species and varieties, only two (*Cymatium sculpturatum* and *Austrotriton cyphoides*) appear to have really close allies in Australian early Tertiary beds, though four others (*A. maorium*, *A. minimum*, *C. revolutum*, and *C. octoserratum*) seem to have more or less distant relatives. It seems apparent that, though the general facies of the New Zealand species resembles that of the Australian fossils, specific differences are considerable, and this suggests that the two sets of forms must have been early segregated from a parent stock that gave rise to both. The fact that none of our Tertiary species occur in Australia is all the more significant since all our Recent species occur there. It is not conceivable that the Cymatiidae could cross the present gulf but not one that existed in the Tertiary; the only explanation is that very different conditions were brought about for a short time after the close of the Wanganuian, and allowed the passage of characteristic Australian forms into our waters. Of whatever character this connection was, it must have been far more pronounced than any that occurred during the Tertiary.

Typhis francescae n. sp. (Plate 49, figs. 6*a*, 6*b*.)

Shell of moderate size, rather thick and stout, of rhomboidal outline. Apex worn, 6 adult whorls left. A carinate shoulder a little below middle on spire-whorls, on periphery in body-whorl. Five varices per whorl, contiguous but not in vertical line on successive whorls, forming spirally backwardly-revolving sharp ridges from apex to body-whorl. Front side of each varix grooved and spinously ridged, a thicker and stronger ridge on shoulder, 7 narrow but strong ridges below, down to base of aperture, each with 2–3 raised foliations; below this varices suddenly diminish and become smooth; above shoulder they are also much diminished and bear 4–5 almost obsolete small ridges. On hinder side varices are smooth except for a little crinkling in centre. At intersection of varix and shoulder is occasionally a small, thick spine, but otherwise the varices are not spinose. At about third of distance between every two varices, nearer posterior one, is a prominent thick and backwardly-projecting hollow tube, considerably higher than varices, situated on shoulder but more above than below it. Tube and rest of shell quite smooth except for growth-lines. Spire regularly staged, somewhat shorter than aperture and canal. Suture linear, inconspicuous, rising to each varix. Aperture small, oval, defined by a strongly-projecting thin and continuous rim, narrower below than above. Tubular perforation situated far within. Canal completely hidden, flatly compressed. Umbilicus slight, fasciole raised and strongly foliar.

Height, 34 mm.; diameter, 23 mm.; height of last whorl, 21·5 mm.; height of aperture, 10 mm.

Type (unique), from Clifden, Southland (band 6A—Ototaran ?), in author's collection.

Larger than most New Zealand examples of *T. maccoyi* T.-Woods, and relatively a little wider and of stouter build, but differing mostly in character of varices, which in Tenison-Woods's species are quite smooth

anteriorly and bear several recurved spines. Not related to any other Australian species. The single fine specimen was collected for the writer by Miss Frances Milnes, after whom it is named.

Trigonostoma waikaiaensis n. sp. (Plate 49, figs. 4*a*, 4*b*.)

Shell moderately large, subscalar. Thirteen axial ribs on body-whorl, rounded, rather low and sloping backwards, not obsolete on upper whorls, interstices about twice their width; they extend over the whole whorl, finer and narrower but still strong on base. Axials crossed by rather flattened spiral cords arranged in regular order; stronger and weaker cords alternate, and on periphery a still finer riblet is interposed between a strong and a weak rib; on shoulder spirals are irregular, gradually becoming finer on approaching suture; about 15 of the strong ribs on body-whorl from shoulder to umbilicus, 5 on penultimate whorl. Spire subscalar, a little lower than aperture. Protoconch lost; whorls at least 5, disproportionately increasing, sloping from suture to a rather strong shoulder at upper three-quarters, thence almost perpendicular to suture below; emerging from suture on base is a blunt angulation, below which body-whorl rapidly contracts. Suture wavy, impressed. Aperture oblong-ovate, squarely rounded above and with a slight notch on shoulder-edge; outer lip effuse below, then narrowed in to form with basal lip a short, narrow, and notched canal, strongly bent to the right. Columella slightly curved, inflected to the right. Inner lip strongly callous, thick anteriorly, but thinning and spreading above parietal wall; interior filled with hard matrix, but extremities of three oblique plaits can be seen, the upper two much stronger. Siphonal fasciole prominent, crenulated by axial ribs, strongly curved, leaving a decided umbilical chink between it and inner lip.

Height, 32 mm.; diameter, 20·5 mm.; height of aperture, 18 mm.

The holotype and two other fragmentary shells, from Waikaia, in author's collection.

The inflection of columella and aperture to right indicates a member of Trigonostominae, and for the present the species may be left in the typical genus, though the umbilicus is much smaller than usual in *Trigonostoma* s. str., and the two upper plaits are the stronger, though a third is distinctly present. Possibly the section *Ventrilia* would be a better location. The subfamily Trigonostominae has not previously been recorded from New Zealand. The Australian shell most like this species is *Merica wannonensis* (Tate), which differs generically in having columella bent to left, and otherwise in its regularly rounded outline below shoulder, the fewer, narrower, higher, and more curved axial ribs, slightly different spiral sculpture, weaker umbilicus and fasciole, and much lower spire, the ratio aperture : spire in the New Zealand shell being 1·3 and in the Australian shell 1·9.

Trigonostoma christiei n. sp. (Plate 49, fig. 5.)

Similar in essential details to previous species, but larger, more staged, and with much more numerous axial ribs. Protoconch of 2 slightly bulbous whorls, almost equal in size, but mamillate tip very small; then a brephic stage of ½ whorl with only spiral cords; then 6 whorls with adult sculpture. Eighteen axial ribs per whorl, of similar character to those of last species, but narrower; interstices 1 2 times the width of ribs. Spirals rather stronger than in *T. waikaiaensis*, but otherwise similar in number, character,

and arrangement, except that a small space close to suture is marked only by waved scratches, and there are 5 or 6 spirals on edge of shoulder separated only by linear interstices. Spire markedly scalar, about same height as aperture and canal. Keel on whorls is level with suture, so that shoulder is quite horizontal. Base and suture as in previous species. Aperture imperfect, outer lip being broken away, but from previous rest-marks it is clear that notch on shoulder-edge was practically absent. Columella lightly curved and bent to right, bearing 3 plaits and a few indistinct ridges outside these, plaits progressively more sloping, the two upper ones strong, but the lowest very weak and almost vertical. Inner lip reflected as thin glaze over parietal wall, and as sharp free edge below fasciole, which forms a broad, rounded, and but slightly roughened ridge enclosing a chink-like but distinct umbilicus. Anterior notch evidently weak, much slighter and less reflected than in previous species.

Height, 40 mm.; diameter, 22·5 mm.; height of aperture, 20 mm.

Type and one much broken larger specimen, from Chatton, near Gore (Waiarekan ?), in author's collection. Named after the collector, Mr. E. M. Christie, M.Sc., of Gore High School.

Closely related to and congeneric with the previous species, but differing from it mainly in the horizontal shoulder, much weaker anterior and posterior notches, and much finer axial sculpture.

Conomitra othoniana n. sp. (Plate 50, figs. 3*a*, 3*b*.)

1917. *Mitra armorica* Sut.: Marshall, *Trans. N.Z. Inst.*, vol. 49, p. 461 (not of Suter).
1918. *Mitra armorica* Sut.: Park, *N.Z. Geol. Surv. Bull. No 20*, p. 102.
1921. *Mitra armorica* Sut.: Suter, *N Z Geol. Surv. Pal. Bull. No. 8*, p. 82.

Shell small, biconic, pointed at both ends, more sharply posteriorly, with finely tuberculate spiral sculpture. Protoconch small and smooth, apex blunt, the two globose turns being very asymmetrically disposed; pullus rapidly swells, first volution very prominent and askew, decidedly overhanging the lower turn and half-covering it on one side, the other side being disproportionately exposed; second volution normally in place with spire-whorls, giving place rather abruptly to their characteristic sculpture. Five to seven lowly convex spiral cords on spire-whorls, interstices a little narrower, on body-whorl ribs remain of this character for a short space below the suture, but periphery bears 4–6 similar but much closer ribs, on remaining half of whorl quite a different sculpture is developed, there being about 11 prominent sharp ribs with wide concave interstices narrower near periphery and canal. Axial sculpture in the form of blunt vertical riblets similar in appearance to spirals, as strong as or stronger than spiral sculpture on earlier whorls; interstices are raised as square granules producing a cancellate *Anachis*-like appearance. Axial ribs tend to die out on body-whorl, their place being taken by sinuous irregularly raised growth-lines, but sharp basal ridges continue prickly. Spire about three-quarters height of aperture, pointed, outlines almost straight (angle about 45°); whorls 7 (including apex), very flatly convex, body-whorl gently rounded, rather suddenly contracted to beak; suture distinct, slightly incised. Aperture oblique, bluntly angled above (suture tends to be more incised with age, thus rounding off aperture posteriorly), truncate below, swelled medially, due to strong curve of outer lip, thin and sharp. Columella slightly oblique, twisted below, with 4 thin but strong oblique plaits, anterior pair much closer and feebler; canal short, open, and lightly notched, fasciole rather prominent. Inner lip drawn out to a fine point below.

Height, 14 mm.; diameter, 6 mm.; height of aperture, 8 mm. Height, 11 mm.; diameter, 4 mm.; height of aperture, 6 mm.

Type and many paratypes, from Target Gully, in author's collection. Not yet found elsewhere.

Has been wrongly identified by Suter as *M. armorica*, from which it is separable at sight. The diagnosis and figure of *M. armorica* Sut. (*N.Z. Geol. Surv. Pal. Bull. No. 5*, p. 27, pl 12, fig. 4) do not agree with this shell, even though many important details are omitted in the description. Actual specimens of *M. armorica* Sut. from Otiake (here figured, Plate 50, figs. 4*a*, 4*b*) show that this is a much smoother, more elongate shell, with a distinct polish, absent in *C. othoniana*. Canal is much longer and altogether different; protoconch also different, being larger, blunter, and more globose. An almost smooth peripheral space is present, as in the new species, but sculpture below and above is the same. Moreover, *M. armorica* Sut. is placed in *Cancilla*, while the new species is a *Conomitra*.

Suter remarks on the resemblance of *M. armorica* Sut. to *M.* (*Cancilla*) *atractoides* Tate, and this is certainly justified, the New Zealand shell differing mainly in details of sculpture. An even closer resemblance to an Australian fossil is shown by the new shell, which resembles *C. othone* T.-Woods so closely as to render its separation a matter of doubt. Authentic Australian shells have not been seen, but judging from the figures (*Trans. Roy. Soc. South Australia*, vol. 11, pl. 4, fig. 10) the body-whorl of the new species is sooner contracted, aperture more dilated, and spiral sculpture not so regular. A more distantly related species is *C. dennanti* Tate.

Conomitra inconspicua (Hutt.). (Plate 50, figs. 2*a*, 2*b*.)

1885. *Mitra inconspicua* Hutton, *Trans. N.Z. Inst.*, vol. 17, p. 326.
1887. *Mitra inconspicua* Hutton, *P.L.S. N.S.W.* (2), vol. 1, p. 212.
1915. *Mitra inconspicua* Hutton: Suter, *N.Z. Geol. Surv. Pal. Bull. No. 3*, p. 20.

This common Waihao species is very closely related to the Australian *Conomitra complanata* (Tate), differing mainly in its longer beak, and therefore relatively lower spire.

Mitra eusulcata n. sp. (Plate 51, figs. 11*a*, 11*b*, 11*c*.)

Shell narrowly biconic, rather thin, protoconch of 3½ smooth turns, high, regularly coiled, bluntly pointed, and not distinctly marked off from brephic stage. First whorl with 3, following whorls with 4, subequal spirals, increasing, through grooving of main ribs, to 8 unequal ribs on penultimate whorl; body-whorl with about 24 unequal spirals, a few of which are grooved medially. The ribs are low and flattish, with much narrower interstices; finer and wider apart near beak. No axial sculpture; punctures in interstices seem also to be absent, but as both shells are slightly worn this cannot be determined for certain. Spire acutely conical, lower than aperture, outlines straight, very slightly scalar. Whorls about 9, flat, regularly increasing, body-whorl bluntly angled at periphery, thence tapering quickly to beak. Suture straight, slightly oblique; whorls worn in its neighbourhood so that it seems slightly subcanaliculate; it is also uncertain whether it is margined. Aperture slightly oblique, long and narrow, slightly channelled above, with short open and truncated canal below. Outer lip convex, acute, smooth within. Columella subvertical, slightly twisted below, with 3 plaits in young shell, 4 in larger specimen; plaits rapidly decrease in strength anteriorly, the last being very weak, they are truncated

by edge of inner lip, which also stops the spiral sculpture. Fasciole fairly distinct.

Heights respectively 16·5 mm., 11 mm.: diameters, 6 mm., 4 mm.; heights of aperture, 9 mm., 6 mm.

Types (two shells), from Target Gully, in author's collection. Not yet found elsewhere.

Has near allies in the Australian *M. multisulcata* Harris,* and especially *M. alokiza* T.-Woods. Details of sculpture and aperture are practically identical, except for the apparent absence of punctures in the New Zealand shell. The Australian shell, however, seems to differ in its smaller protoconch ("two small, narrow, rounded turns") and in its dimensions, being much more elongate and having a spire higher than aperture. Harris (*Cat. Tert. Moll. Brit. Mus.*, pt. 1, p. 120) gives the dimensions of an Australian specimen as—height, 66 mm.; diameter, 16 mm.; height of aperture, 28 mm. The new species is also not so markedly angulate on periphery.

Mitra elatior n. sp. (Plate 50, figs. 5*a*, 5*b*.)

Shell in form and sculpture so close to the previous species that it is best described by comparison with it. Protoconch narrower and higher and apparently has an extra turn. First whorl with 5 spirals, increasing later to 6 and then 7 on penultimate whorl; body-whorl with about 20 unequal spirals. Interstices vary from one-half to one-third of ribs in width on periphery, but almost as wide as ribs on base; ribs as in previous species. The shells are not worn, and interstices are finely punctate, due to presence of axial threads which do not appear on ribs; thus it is probable that well-preserved specimens of *M. eusulcata* would show punctation also. Shell is noticeably narrower than in that species and more elongate, shape being narrowly fusiform rather then biconic. Whorls are also much more loosely coiled, the tightly-wrapped appearance of *M. eusulcata* being absent. Body-whorl has no blunt angulation, but is very lowly convex and then contracted to beak much lower down than in the other species. The presence of the perfectly straight supra-peripheral area in *M. eusulcata* makes the spire-area almost a plane surface, hardly interrupted by sutures, but in *M. elatior* convexity of whorls makes sutures appear distinctly incised, although outlines of spire remain straight. Spire is also considerably higher than aperture. Internally, columella bears 5 plaits instead of 4, the uppermost being much the strongest and somewhat removed from the others. Very young shells bear 4 narrow but high plaits (the highest remaining farther away) instead of 3 stout ones. Outer lip quite different inside, being strongly lirate with about 9 very narrow but rather high ridges, many times their width apart.

Height, 19 mm.; diameter, 6 mm.; height of aperture, 9 mm.

Type and several paratypes, from Clifden, Southland (band 6c—Ototaran ?), in author's collection.

Uromitra etremoides n. sp. (Plate 50, figs. 6*a*, 6*b*: Plate 51, figs. 10*a*, 10*b*, 10*c*.)

Shell small, elongate-fusiform, with strong discontinuous axial ridges and fine close spirals. Protoconch pupiform, of 3 almost symmetrical smooth whorls, bluntly pointed, distinctly marked off from brephic stage. Spiral ribs very obscure on earlier whorls, 4 on first, 5 on second, and 6 on the

* Dennant and Kitson (*Rec. Geol. Surv. Vict.*, vol. 1, p. 101) reduce this species to a variety of *M. alokiza* T.-Woods.

rest, sometimes 7 on penultimate, 16 spirals on body-whorl; spirals lowly convex, interstices varying in width, seldom linear, usually subequal to ribs, widening near beak. Axial ribs numerous and irregular in brephic stage, but soon following each other regularly, 7–9 per whorl; generally they are in line with those on contiguous whorls, but slope a little backwards, vanishing on lower half of body-whorl; interstices usually slightly wider. Axial ribs very much stouter and more prominent than spirals, which cross them without forming nodules. Growth-lines rather conspicuous, spire narrowly conic, outlines straight, in young shells one and a third times height of aperture, in adult shells more than one and a half times. Whorls 10, body-whorl subangulated below periphery, then suddenly contracted towards beak. Suture impressed, undulating, submargined by narrow band. Aperture narrowly ovate; high, acutely subangled above, produced below into a short oblique canal with straightened base. Outer lip convex, thin and sharp. Columella straight, vertical, with 3 oblique, strong plaits, decreasing in size anteriorly.

Height, 14 mm.; diameter, 4 mm.; height of aperture, 5½ mm.

Type and ten paratypes, from Target Gully, in author's collection.

This *Vexillum* bears comparison with no New Zealand or Australian Tertiary shells; its characteristic sculpture is reminiscent of the Turrid genera *Etrema*, and especially *Pseudoraphitoma*. Young shells are probably confused in existing collections with *Vexillum fenestratum* Sut., to which they bear a deceptive resemblance, but they can at once be distinguished by the different protoconch and strong columellar plaits.

Lyria zelandica n. sp. (Plate 49, fig. 7.)

Shell of moderate size, ovately biconic, thick, and solid. Apex broken off, remaining adult whorls 6, very lightly convex and a little contracted at lower suture, body-whorl regularly convex, gradually contracting to base. Faint indication of shoulder, midway on spire-whorls, a little below suture on body-whorl. Outer lip swollen by prominent low and wide varix. Sixteen vertical axial ribs per whorl, continuous over all whorls, extending from suture to suture on spire, and almost down to fasciole on body-whorl; ribs prominent, narrowly rounded, but not jutting, smoothed off into flattish or concave interstices which are about twice width of ribs. Axial ribs reduced in size on base and curving round from vertical to horizontal direction on fasciole, projecting slightly at upper suture on all whorls as very low blunt points. No spiral or other sculpture except for growth-lines. Suture impressed, slightly sloping, and rapidly undulating. Spire conic, of almost straight outlines, half height of aperture. Aperture oblique, long and rather narrow, widest medially, the two sides approximately parallel, bluntly pointed and with very slight notch above, thickened below, and forming a broad, shallow, slightly emarginate canal, bordered at base by sharp edge. Outer lip thick and solid, with flattish edge, slightly rising on penultimate whorl. Inner lip restricted and with definite boundary, expanded most medially, thence forming raised blunt edge descending vertically to meet columellar margin in a point at base of canal and proceeding round canal as a sharp margin; on parietal wall inner lip thickens into strong callus at junction with outer lip. Columella practically straight, but oblique in same direction as aperture, rather massive, with three strong plaits on lower half and numerous fine ridges above these. Plaits not very oblique, tending to become quite horizontal or even curving upwards on emergence on inner lip; centre plait a little the strongest.

Height, 41 mm.; diameter, 22·5 mm.; height of aperture, 28 mm.

Type (unique), from Clifden, Southland (band 6c—Ototaran ?), in author's collection.

Although several New Zealand Volutes have previously been placed in this genus, they cannot remain there, and up to the present there has been no undoubted record of *Lyria* from this country. The above species is a fairly typical member of the genus, and cannot be confused with any previously described species. It is not nearly related to any Australian shell, but has a distant likeness to *L. harpularia* Tate, also to the European species *L. maga* (Edw.) and *L. harpula* (Lamk.).

Solecurtus bensoni n. sp. (Plate 50, figs. 8*a*, 8*b*.)

Shell thin and fragile, shining, transversely elongate-oblong, gaping considerably at both ends and dorsally, moderately tumid, considerably depressed ventro-medially; inequilateral, posterior end much longer, anterior side not narrower than posterior, but flexed to left in both valves. Anterior dorsal margin perceptibly sloping and faintly curved; posterior dorsal margin straight, but suddenly rising a little to beak; ventral margin with very slight incurvation medially, corresponding in position to depression in tumidity of shell, curving up more abruptly before than behind. Posterior end almost semicircular in outline, anterior squarely rounded. Umbos small, approximate, a little tumid and pointed, interrupting the regular outline of hinge and marked off by a slight shallow groove on either side, projecting slightly but distinctly beyond dorsal margin. Previous outlines of shell thrown into prominence here and there by light and dark bands. Radial ornamentation of very faint and dense scratches, radiating from umbo on each side of a perpendicular dropped from beaks, much more rapidly slanting and diverging on posterior part and producing there distinct faint raying, especially about the blunt posterior ridge limiting median depression in shell. Anterior division divided approximately into halves by another very low and blunt angulation running from umbo to antero-ventral corner; in front of this radial lines form the only ornamentation, but they are not seen without lens; behind this and over the rest of shell surface is cut into many shallow steps, descending posteriorly, by sinuated engraved lines running to ventral margin from a line drawn from umbo to middle of posterior end. On anterior part of shell the slope of the lines is parallel to that of the limiting low angulation; lines posterior to this gradually swing out till on posterior end they slope in reverse direction, though less strongly; on posterior line from umbo they bend back and run at first subparallel to dorsal margin, but the bending-angle becomes more acute the farther it is from beak till at posterior end lines meet the rounding margin almost vertically. Interior polished, especially muscle-scars and pallial line. Anterior muscle-scar slightly larger, subpyriform, posterior rounded trigonal. Pallial line sloping in downward curve from anterior scar, ending abruptly at considerable distance below posterior scar. Pallial sinus linguiform, very deep, reaching half-way between anterior scar and the vertical from beaks. Left valve with a long sharp upturned cardinal tooth just anterior to umbo, and a sloping low and bifid tooth posterior to it. Interior of right valve not seen

Length, 2·85 mm.; height, 11 mm.; thickness (two valves), 6·5 mm.

Type and several more or less broken paratypes, from Clifden, Southland (band 6A—Ototaran ?), in author's collection. Although the shell is fairly common at this locality, perfect specimens are not easy to obtain, owing

to its fragility. The type is the only perfect and double-valved specimen so far obtained.

Genus and species new to fauna, though it is a very widely spread genus, and three fossil members have already been described from Australia. Of these, *S. legrandi* Tate is very close to the new species, presenting the same type of grooving and differing in only a few details. Tate gives its dimensions as "Height, 40 mm.; width, 17·5 mm."—a ratio of 2·29 : 1; but his figure measures 40·5 × 16·75 a ratio of 2·42 : 1. The ratio in *S. bensoni* is 2·95 : 1, so that this species is relatively longer than *S. legrandi*, which seems to differ also in the absence of ventral incurvation, less prominent umbos, inconstant height (greater posteriorly), recurved posterior dorsal margin, and slightly different slope of sculpture-lines, which dorsally are not initially subparallel to margin, and ventrally do not reverse in direction on posterior end. From *S. dennanti* Tate and *S. ellipticus* Tate the new species is easily distinguished by the character of grooves. This elegant New Zealand species is with much pleasure dedicated to Dr. W. N. Benson, friend and former teacher of the writer.

Solecurtus evolutus n. sp. (Plate 50, fig. 9.)

Evidently a direct descendant of the previous one, occurring at the same locality in beds geologically a little younger. It agrees with it in all main features, but is slightly more solid, decidedly shorter (especially the posterior end), and higher, with slightly less numerous but stronger and more conspicuous grooves. On anterior end grooves cease with one or two much shorter but not closer grooves, instead of, as in *S. bensoni*, several long grooves close together. The species seems also less flattened medially.

The best-preserved specimen, chosen as holotype, is still considerably fractured, so that its dimensions are somewhat hypothetical: its greatest length is 31·5 mm., greatest height 15·5 mm., and greatest width (one valve) 4·5 mm If one measures from the largest perfectly intact growth-line the dimensions are 22 mm., 10 mm., 2·5 mm.

Type, a right valve, from Awamoa beach-boulders (Awamoan), in author's collection. Other small fragments were obtained here, at Pukeuri, and at Target Gully. Also some larger fragments from Clifden (band 7c —Hutchinsonian ?) which differ from *S. bensoni* of a lower band in the same respects as does the type. That this genus has not been recorded previously is due probably more to the fragility of the shell than to its rarity; the sculpture, however, is distinct and characteristic on even tiny fragments. The present species has the ratio length : height a little over 2·2 : 1, and this brings it even closer than the previous species to *S. legrandi* Tate. The author's thanks are due to Mr. Chapman, of the National Museum, Melbourne, for comparing a photograph of the type and some fragments of the shell with the type of Tate's species; he agrees with the author that the two forms are distinct, though very closely related.

Solecurtus chattonensis n. sp. (Plate 50, fig. 10.)

At once distinguished from the two preceding species by its proportions and the different character of grooves. Anterior side relatively much longer, being over three-quarters the length of posterior side, while it is under two-thirds in the other species. The shell is also still shorter in regard to height than *S. evolutus*. The grooves are only half as numerous and have a different disposition: there are only 17 grooves altogether in the type, while *S. bensoni* of similar size has about 35 and adult shells

have at least 50; the type of *S. evolutus* at a stage comparable to *S. chattonensis* has 26. There are no shorter or closer grooves at first, the transition from the smooth anterior area to strong equidistant grooves being abrupt. Grooves oblique in same direction as initially over most of surface, instead of rapidly swinging round to reverse direction, and the bending-angle above posterior ridge is very slight, the lines remaining always steeply inclined to dorsal margin. All the grooves are stronger, and do not get closer posteriorly, but indeed considerably wider apart, and do not become weaker. Shell is much flatter, especially anteriorly; medial depression not so marked, but valve more flatly depressed postero-dorsally. Growth-lines and rest-periods are much fainter.

Length, 16 mm.: height, 7·5 mm.; width (one valve), 1·5 mm.

Type (unique), from Chatton, near Gore (Waiarekan?), in author's collection.

Although the single specimen is juvenile and incomplete, it differs strikingly from the other two species. The ratio of length to height is only 2·13 : 1. The ratio of anterior to posterior side in the three species described may be tabulated as follows:

Species.	Anterior Side.	Posterior Side.	Ratio
S. bensoni . .	10 mm.	18·5 mm.	1·85
S. evolutus	8·5 mm.	13·5 mm.	1·6
S. chattonensis ..	7 mm.	9 mm.	1·3

Barytellina anomalodonta n. sp. (Plate 50, figs. 7*a*, 7*b*, 7*c*.)

Shell rather small but very thick and solid in shape like an obliquely truncated ellipse, no anterior lateral teeth, right valve with a large posterior cardinal tooth. Beaks contiguous, sharp, but not prominent, dorsally flattened, directed slightly backwards. Anterior end slightly longer; starting from beaks a regular elliptical curve is described until nearing posterior end, when ventral border shows a slight sinuation due to external posterior fold. Posterior end straight, making an angle of about 120° with antero-dorsal edge; it meets upcurved ventral border at angle of about 80°, apex being narrowly rounded off; is flexed to left in right valve, and *vice versa*. External surface appears at first sight smooth and polished, but under lens shows roughening due to extremely fine and dense growth-lines; there are also very inconspicuous narrow and flattish radial riblets with interstices of quite variable width; these riblets are so little raised as to appear more like rays on surface, and, combined with shape of shell, give it a superficial resemblance to *Leptomya perconfusa* Iredale. There is a strong posterior fold in each valve; this grades gently on anterior side into a wide and shallow sinuation which occupies most of posterior end in right valve but is narrow and subobsolete in the more convex left valve, on posterior side it is bounded by a much narrower, cord-like secondary fold from which there is a vertical drop to the straight dorsal margin. A flat lanceolate area is thus formed when the two valves are in conjunction, bearing a strong resemblance to the escutcheon of a *Nuculana* In left valve an additional slight fold traverses this area close to ligament, which is fairly deep-seated, the well-developed nymphs easily visible from exterior. Interior very uneven, suddenly thickened below pallial line, also in places near hinge. Adductor-scars deeply impressed, especially the posterior, which is subrhomboidal; the anterior elongated, pyriform. Pallial sinus

linguiform, reaching anterior scar and occupying more than half of body-cavity. Margins smooth, sharp. Right valve with two cardinals, the anterior a thin lamina subparallel to dorsal margin; the posterior a large elevated trigonal mass, projecting far above hinge-level and into interior, obsoletely grooved on top; it has the appearance of a Mactrid resilium. Posterior lateral also very large and prominent for the genus, forming a short stout ridge, far removed from cardinal teeth. No anterior lateral tooth in this valve, hinge forming a plain bevelled surface, overhung by dorsal margin; left valve with two cardinals, the anterior moderately strong, elevated, posterior weaker, a trigonal lamina. Posterior lateral very large, trigonally raised, in shape reminiscent of laterals of *Lasaea*. Traces of an anterior lateral are indicated by a very slight ridging of the dorsal margin.

Length, 26 mm.; height, 21 mm.; width (one valve), 6 mm. Length, 24 mm.; height, 20 mm.; width (one valve), 5 mm.

Types (two vales), from Rissington, Hawke's Bay (Pliocene), in author's collection collected by Dr. Benson. Also paratypes from Glengaree, Napier.

This shell is unlike any previously described from New Zealand, and, on account of its dental peculiarities (very large posterior cardinal and lateral of right valve, and absence of anterior lateral), Mr. Marwick has created for it and a related species the new genus, *Barytellina*, with the Nukumaruian *B. crassidens* Marw. as type (*Proc. Mal. Soc.*, vol. 16, p. 25, 1924.)

Macoma robini n. sp. (Plate 51, figs. 6*a*, 6*b*, 6*c*.)

Shell trigonally oval, thin, inequilateral, much compressed, with fine sharp concentric sculpture. Beaks behind middle, raised and very sharp, pointing inwards and backwards. Anterior end longer, semi-elliptical, dorsal margin very lowly convex and slowly descending; posterior end attenuated, trigonal, dorsal margin slightly concave and obliquely a little truncated just before meeting the broadly and regularly rounded ventral margin, slightly flexed to right in right valve and *vice versa*, the right valve most inflated anteriorly, left posteriorly. Sculpture consisting of fine close sharp concentric ribs, about 5 per millimetre at 20 mm. from beak. Sculpture very distinct, ribs appearing linear, but examination with lens showing that there is great variation in their width, some being comparatively flattish with sublinear interstices, but all having a sharp dorsal edge. Right valve has 2 rather weak folds with a narrow separating groove very near posterior dorsal margin; left valve has 2 similar but narrower folds; on all these the concentric riblets are strongly raised and quite irregular. Right valve with 2 cardinals, posterior bifid, a strong lateral rather distant from anterior cardinal and a weaker one below nymph; left valve with a weak anterior cardinal and rudimentary posterior one, laterals obsolete. Ligament fairly long, strong, Interior filled with matrix.

Height, 25 mm.; length, 39 mm.; width (two valves), 6 mm.

Type and four paratypes, from Otiake (Hutchinsonian), in the author's collection. Collected by Mr. R. S. Allan, whose name is attached to the species.

The shell has some resemblance in shape to *Tellina gaymardi* Iredale, but this has anterior end shorter and a smooth appearance. The nearest relative seems to be *Macoma edgari* Iredale, and it is on account of its relationship with this species, especially in hinge, that it is placed in

Macoma rather than in *Tellina*. It differs, however, from the Recent species in its finely ridged appearance, less inflation and elongation, and unstraightened basal margin. It has also some resemblance to the Australian *T. albinelloides* Tate.

Genus ATAXOCERITHIUM.

Ataxocerithium pyramidale n. sp. (Plate 51, figs. 7*a*, 7*b*, 7*c*.)

Shell small, regularly conical, with nodulous cancellate sculpture and sharply angled periphery. Protoconch of about 3 smooth but apparently worn conical whorls (nucleus lost), marked off from brephic stage by a slight varix; the following 1¼ whorls have only gradually strengthening concave axial riblets, about their own width apart; from this point spiral sculpture begins and rapidly gains prominence. Three main spirals on all whorls (interstices variable but generally much wider), but sooner or later weaker interstitial ribs arise between lower or both pairs of main ribs, and a very faint rib may develop just below suture. Just below periphery on body-whorl an additional rib arises out of suture, and immediately below this there is another rib (exceptionally two faint ribs); both these crenulated. About two-thirds across base a small smooth rib encircles columella, interstices between all basal ribs concave. Axial ribs continue concave and blunt for short distance, but soon become straight and sharply angled, interstices thus appearing wider. They are not quite continuous over the whorls, number about 23 on last whorl, and at intersections with spirals form sharp nodules; they cease just below periphery. Spire about 1½ times aperture with canal, angle about 40°, outlines quite straight. Whorls, apart from protoconch, about 6, regularly increasing, flat, body-whorl sharply angled at periphery, base flattish. Suture canaliculate. Aperture subrhomboidal, interrupted below by a narrow small canal, bent backwards and strongly to left. Outer lip broken. Columella vertical with strong fold margining canal and weaker subparallel one a short distance above it. Inner lip highly callous, spreading over parietal wall and a short distance beyond columella, sharply limited.

Height, 6·5 mm.; diameter, 4 mm.

Type and several paratypes, from Target Gully (Awamoan), in author's collection. Also occurs at Ardgowan; Pukeuri; Awamoa Beach; Clifden, Southland (band 6c—Ototaran ?); and Pourakino, Riverton.

Subspecies **robustum** n. subsp.

Differs in its rather wider spire (angle about 45°) and less cancellate appearance, due to weaker spirals but stronger axials. These are slightly blunter and fewer (about 18 on body-whorl), so that interstices are wider. Otherwise there is no difference.

Height (estimated), 7 mm.; width, 4·5 mm.

Holotype (upper whorls lost and columella damaged), from Taradale Bridge (Hawke's Bay—Pliocene), in the author's collection.

Ataxocerithium nodicingulatum n. sp. (Plate 51, figs. 8*a*, 8*b*, 8*c*, 8*d*.)

Shell moderately small, irregularly conical, with nodulous cancellate sculpture and rounded periphery. Protoconch, obliterated in most specimens, of a few conoidal turns, several whorls follow, ornamented only with flexuous axial ribs. At initiation of cancellate sculpture are 2 bold spirals, quickly increasing by intercalation on later whorls to 3, 4, and up to 9 or

11 subequal spirals on body-whorl and extending over base; interstices wide while the ribs are few but narrower when they are many; towards canal ribs become fainter and smoother. Axial sculpture consists on the upper whorls of rather bluntly rounded ribs (about 20 per whorl) with considerably wider interstices, intersections with spirals raised into vertically compressed nodules, but on body-whorl axials quickly diminish in size and prominence and crowd together, becoming of same strength and width apart as spirals so that a much finer cancellation is produced. At same time whorls become slightly discontinuous, body-whorl appearing greatly narrowed, so that shell presents a characteristic appearance near aperture. Spire more than twice height of aperture, sharply pointed; angle about 35°, but this is variable spire being slightly concave above, then swelling out, then contracting on body-whorl, and suddenly diminished on base; the different changes in outline and direction impart a somewhat Eulimelloid appearance to shell. Whorls (apart from protoconch) about 8 or 9, early ones flat, later ones convex, body-whorl regularly rounded to convex base. Suture deeply incised, often canaliculate. Aperture subovate, angled and channelled above, produced below into a short deep canal, twisted backwards and to left. Outer lip regularly and strongly convex. Columella vertical, with strong plait margining canal and generally another strong one medially, not parallel to lower one, and sometimes almost obsolete. Strong plait on parietal wall near outer lip, which bears a series of teeth some distance within aperture; these, however, are not well developed unless outer lip is thickened. Inner lip spreading as a well-defined callus over parietal wall, part of base, and beyond columella, forming there a distinct cavity but no umbilicus.

Height, 7·5 mm.; diameter, 3 mm. (holotype). Height, 11 mm.; diameter, 4 mm. (paratype).

Type and many paratypes, from Target Gully, in author's collection. Also from Pukeuri, Ardgowan, and Awamoa Beach.

In sculpture this shell is almost the same as *A. pyramidale*, and there is the possibility that it is only the gerontic form of this species. This might explain such differences as rounded periphery, change of ornament near aperture, &c.; but the inconstant spire-angle and direction, more slender shell, and different implanting of upper columellar plait seem to remove it from the other species. Moreover, the two forms, though occurring together in the same localities, are so readily distinguishable in all stages by shape of periphery that it seems best to treat them at present as distinct species.

Ataxocerithium quadricingulatum n. sp.

Shell fairly small, with nodulous cancellate sculpture and bluntly angled periphery. Apical whorls and outer lip lost. Four narrow and blunt spirals per whorl, interstices wider; another rib emerges on base from suture and two more at equal distances below this, finer riblets appear on neck of canal, and between each pair of main ribs there is near aperture a finer interstitial riblet. Narrow and rather sharp axial ribs (about 25 on body-whorl) cross spirals and are raised at intersections into blunt tubercles. Only the four main riblets on body-whorl are prominently tuberculate, the next one is much less strongly nodulous, and remainder almost smooth. Angle of spire apparently about 35°. Suture incised. A strong columellar plait margins canal, which is long and twisted.

Height, ?; width, 5 mm.

Type, from Petane, in collection of New Zealand Geological Survey.

This shell was included by Suter amongst specimens of *A. suteri* Marwick and labelled "*Newtoniella* n. sp." It has strong affinity with *A. nodicingulatum*, from which it is probably descended, just as *A. pyramidale* subsp. *robustum* may be the successor to *A. pyramidale*. It is distinguishable, however, by its less prickly nodules, unchanged body-whorl sculpture, differently shaped canal, and apparent absence of an upper columellar plait. It also has analogy with *A. huttoni* Cossm., though this has different spiral sculpture.

Besides the four new species or varieties of *Ataxocerithium* described above, four others have been named from the New Zealand Tertiary. These are *A. huttoni* Cossm., *A. perplexum* M. & M., *A. suteri* Marwick, and *A. tricingulatum* Marwick.

A. huttoni Cossm. is readily distinguished by its low and convex spirals with narrow interstices, the spirals being practically confined to base and spaces between axial ribs. Axials numerous, sloping forward, sharply convex, and without nodules, interstices a little wider. There are 5 spirals per whorl and about 7 more on base; axials number about 30 on body-whorl. Shell is fairly large and relatively wide, angle of spire about 45°. Locality, Castlecliff. The type, which was stated by Suter to be apparently lost, has been rediscovered amongst the Geological Survey material, and is now in that collection. The writer agrees with a manuscript remark by Mr. Marwick regarding this species: "The locality, Hampden, given by Hutton and Suter should be deleted, as Dr. Marshall's extensive collections have given a better idea of that fauna." The Hampden record is possibly based on a fragment of the somewhat similar *Alectrion socialis* (Hutt.), which does occur there.

A. perplexum M. & M., described by Marshall and Murdoch* from Nukumaru, is really a *Cerithidea*, very close to *C. bicarinata* Gray, and is possibly only this species with the keels rubbed off. Many specimens of *A. perplexum* M. & M. have been found during the last year, but all are highly polished and worn, and until the discovery of better-preserved specimens Marshall and Murdoch's species should stand, as *Cerithidea perplexa* M. & M.

A. suteri Marwick: This species is described on page 195 of this volume. It comes from Okawa Creek shell-bed, Ngaruroro River (Geol. Surv. loc. 1063), and also from Petane, and is a very distinct form. Its exceptionally tall spire (angle about 20°) characterizes it at once: there are 3 coarsely-nodulous cinguli per whorl, and 3 more on base, nodules are in line on successive spirals, and roughly indicate axial ribs as strong as spirals, interstices between spirals and axials are sublinear. A figure of this species (Plate 51, figs. 9*a*, 9*b*) is given in order that its characteristic sculpture may be contrasted with that of the other species described.

A. tricingulatum Marwick, from the same locality (Okawa Creek), is also described in this volume (p. 194). It is very similar to the previous species in sculpture, but axial ribs are more distinct and numerous, nodules smaller and finer, and the three basal ribs almost smooth. It is at once distinguished by its shape, the spire being much less acute (angle about 35°) and suture much more deeply incised. Besides the type, only two specimens from Nukumaru (in author's collection) are known.

* P. MARSHALL and R. MURDOCH, Some New Fossil Species of Mollusca, *Trans. N.Z. Inst.*, vol. 51, p. 254, 1919.

KEY TO THE NEW ZEALAND SPECIES OF ATAXOCERITHIUM.

Shell acicular, spire more than three times height of aperture ..	*A. suteri.*
Shell not so elongate, spire not more than twice height of aperture.	
(1.) Axial ribs smooth, much more prominent than spiral ribs which are confined to base and interstices ..	*A. huttoni.*
(2.) Axial ribs nodulous.	
(A.) Periphery sharply angled.	
Spirals equally nodulous.	
Axials rather weak and narrow ..	*A. pyramidale.*
Axials strong and wide	*A. pyramidale* subsp. *robustum.*
(B.) Periphery convex.	
(AA.) Four or more spirals per whorl.	
(*a.*) Periphery regularly rounded, rather finely cancellate appearance	*A. nodicingulatum.*
(*b.*) Periphery subangled, rather coarsely cancellate appearance	*A. quadricingulatum.*
(BB.) Three spirals per whorl	*A. tricingulatum.*

Chione (s. str.) **crassitesta** n. sp. (Plate 50, figs. 1*a*, 1*b*, 1*c*.)

Shell trigonally ovate, extremely swollen and solid, radial and concentric ornament prominent. Beaks very prominent, inflated, situate at anterior third of length. Anterior end shorter, angularly ovate, dorsal margin twice strongly sinuated. Posterior end subangled in two places, obtusely dorsally and relatively much more acutely ventrally; basal margin flatly rounded. Lunule heart shaped, fairly distinct, short but extremely wide. No escutcheon. Strong squarely rounded radial ribs cross the whole surface, becoming subobsolete posteriorly (about 30 can be counted on the type; in *C. stuchburyi* (Gray) they reach 40 or more). Very prominent foliaceous concentric ribs decussate the radial sculpture, are rather narrow (interstices two to three times their width), and are most strongly developed antero-medially. (In *C. stuchburyi* (Gray) concentric ribs are much finer, sharper, and more numerous.) Margins finely crenulate except posteriorly, crenulations regular, but indications of development of coarser ridges on posterior ventral part; this has taken place in *C. Stuchburyi* (Gray). Hinge very solid and strong; similar to that of *C. stuchburyi* (Gray) except that anterior cardinals in each valve are more nearly vertical, other cardinals are relatively stouter and more deeply cleft, and hinge-line projects farther into shell beneath median tooth. Nymphs very strong and prominent. Posterior adductor-scar slightly larger, but the anterior more sunken. Pallial line distinct, distant from margin, sinus short and acutely trigonal.

—	*C. crassitesta* nov.	*C. stuchburyi* (Gray), Normal Form.	*C. stuchburyi* (Gray) var. Auckland Islands.
Length .. .	47 mm.	47 mm.	65 mm.
Height	43 mm.	40 mm.	50 mm.
Width (two valves) ..	43 mm.	20 mm.	36 mm.

Holotype, from Clifden, near Cape Kidnappers (Pliocene), in author's collection—collected by Dr. Benson. Paratypes in Otago University School of Mines collection.

The nearest Recent relative to this shell is the massive variety of *Chione stuchburyi* (Gray) found at the Auckland Islands. From this it is easily distinguished by its different dimensions, lunule, sculpture, and pallial sinus. Mr. Marwick has collected, in the Hawke's Bay District, great numbers of a form which in thickness is intermediate between *C. stuchburyi* (Gray) and the present species, but otherwise is nearer the Recent shell. Since typical forms of *C. stuchburyi* are found fossil in the Greta beds, which are older than those at Clifden, *C. crassitesta* is probably not ancestral but an offshoot from the *C. stuchburyi* line.

Conus (Lithoconus) triangularis n. sp. (Plate 48, figs. 10*a*, 10*b*.)

Shell small, apparently rather thin and fragile. Protoconch lost in both specimens seen, but apparently projecting above perfectly flat spire. Whorls at least 6, with linear sutures hardly distinguishable from sculpture-lines, horizontal above, but acutely keeled at periphery of body-whorl, forming an almost perfect angle of 65°, then rapidly sloping to canal, but slightly indented in two places—just below keel and a little above canal. Spire-whorls, and that part of body-whorl above keel, bear 4 strong spiral cords, of which inner and outer are wider and flatter than middle pair; the rest of body-whorl covered over whole surface with rather strong and closely-set spiral cords, low and rounded, a little less than their own width apart. Aperture filled with hard matrix, but evidently very narrow; columella twisted in front. Posterior sinus, as indicated by lines of growth, is apparently extremely shallow, and removed from suture.

Height, 16 mm.; width, 15 mm. The paratype has the corresponding dimensions 17 × 16½ mm.

Type and one paratype, from Kakanui (on the beach near the quarry, from tuffs below the limestone), in author's collection.

This is the second representative of *Lithoconus* that has been found in New Zealand. *Conus* (*Lithoconus*) *abruptus* Marshall occurs at Pakaurangi Point, but the Kakanui shell is not related to it except subgenerically, differing in its squat shape, much more acute keel, and totally different sculpture. Here, again, the nearest ally is Australian, *Conus* (*Lithoconus*) *dennanti* Tate, of Balcombian and Janjukian beds, and these two are very closely allied. The crown of *C. dennanti* is a little concave, that of the New Zealand shell almost perfectly plane. Harris (*Cat. Tert. Moll.*, pt. 1, p. 33) comments on the sharpness of the keel of *C. dennanti*; that of our shell is sharper still and the angle somewhat smaller. The Australian shell is rather elongate (33 × 20 mm.), approaching more the shape of *C. abruptus* Marshall (20 × 11 mm.), the ratios of height to width being—*Conus abruptus* Marshall = 1·82; *Conus dennanti* Tate = 1·65; *Conus triangularis* Finlay n. sp. = 1·07. The sculpture, keel, and spire of *C. dennanti* Tate, however, remove it from the vicinity of *C. abruptus* Marshall, but indicate its very close relationship to *C. triangularis* Finlay n. sp., the differences being in degree alone.

New Zealand Tertiary Rissoids.

By H. J. Finlay, M.Sc., Edmond Fellow of Otago University.

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Rissoids are not usually plentiful as fossils in New Zealand. In the latest list of our Tertiary Mollusca (Suter, 1918) nine species of *Rissoa* and *Rissoina* are recorded; five of these are also Recent species, and only one of the other four is from the Miocene. In the present paper the number of Rissoids recorded as fossil from New Zealand is raised to twenty-five, fifteen of these being described as new, most of them being from Miocene beds.

Hutton (1873, 1885, 1893) was the first to describe members of this family from the New Zealand Tertiary: five of the nine species above mentioned were originally described from the Pliocene beds of Petane or Castlecliff, one from Awamoa (Miocene), and the remaining three were discovered fossil subsequent to their description as Recent species. The only addition made to this number in recent years is *Rissoina (?) obliquecostata* M. & M., described by Marshall and Murdoch (1920a) from Hampden.

Although these small shells are termed Rissoids, Iredale (1915) has shown that the type name, *Rissoa*, should not be applied to any Neozelanic shells, and has provided a series of generic names to cover austral forms. His scheme marks a decided advance in their treatment, and by it New Zealand Recent Rissoids can be reduced to some semblance of order. Strong support for his action is given by the ease with which practically all the fossil Rissoids so far discovered fall into his groups. Iredale might, however, have been more generally explicit in defining his genera. It may be legally correct to define a new genus—*e.g.*, *Merelina*—by "proposing it for shells grouped around *Rissoa cheilostoma* Ten.-Woods," but this is extremely unsatisfactory for workers who have not access to large suites of actual specimens, and have to rely mostly on literature. To ensure immediate appreciation and acceptance of new genera a *résumé* of diagnostic characters is imperative. From Iredale's treatment of the Rissoids it was almost inevitable that when his names did come into use some of them should be misapplied, and this has already occurred. The genus *Estea*, in particular, seems to have given trouble—the writer has seen one of the spirally lirate species determined as a *Subonoba*; and, further, Marshall and Murdoch (1920b) have listed *Rissoa semisculcata* Hutt. as a *Lironoba*, to which genus it bears little resemblance. As far as the writer can see, the following diagnostic notes (compiled after study of New Zealand Recent and fossil species) represent Iredale's ideas fairly correctly; he would, however, have saved Neozelanic workers much trouble had he given a similar table when his genera were proposed.

(A.) "RISSOA" GROUP.

Aperture generally suboval and entire; basal lip hardly channelled or effuse.

1. Shell thin; axial sculpture prominent (broad low ribs, interstices rather wide and either smooth or with slight spiral sculpture); protoconch smooth, globose, whorls convex; aperture rotund and subvertical, peristome continuous. *Haurakia.* **Type, *H. hamiltoni* (Sut.).**

2. Shell moderately solid, clathrate (distant fine spiral ribs, crossing and rendering nodulous the axial ribs, which are also rather distant, wide but with a sharp edge, base generally with a few smooth spirals); protoconch papillate, spirally striate; whorls convex; aperture oval, oblique, heavily variced, peristome continuous, internally duplicated. *Merelina.* **Type, *M. cheilostoma* (Ten.-Woods).**

3. Shell similar to *Merelina*; protoconch smooth and glossy, dome-shaped; aperture thin-edged, rather simple, with or without varix behind, rim not duplicated. *Linemera* **n. gen. Type, *L. interrupta* Finlay (nom. nov. for *R. gradata* Hutt., preocc.).**

4. Shell thin, semitransparent; fine and weak axial and spiral sculpture visible through the aperture; protoconch smooth, dome-shaped; whorls lightly convex; aperture ovate-pyriform, the peristome discontinuous, thin and sharp. *Onoba.* **Type, *O. striata* (Montague).**

5. Shell thin, translucent; cut up into weak spirals by grooves, no axials; protoconch smooth, papillate, whorls slightly convex; aperture subvertical, ovato-pyriform, peristome continuous, thin and sharp. *Subonoba.* **Type, *S. fumata* (Sut.).**

6. Shell very solid; very heavily lirately sculptured (spiral ribs much raised and flatly rounded, continuing over the whole surface, interstices deep and broad); protoconch smooth (or spirally lirate?); whorls convex; aperture oval, heavily thickened, peristome continuous, internally duplicated. *Lironoba.* **Type, *L. suteri* (Hedley).**

7. Shell solid; strong spiral keels, the intervening spaces with dense axial foliations; protoconch spirally striate; whorls strongly shouldered; aperture rounded; peristome continuous, thick and blunt. *Anabathron.* **Type, *A. contabulatum* Frfld.**

8. Shell solid; sculpture not prominent, and when present generally confined to the lower whorls. (The whole surface may be smooth, or traces of spiral grooves may be present; there may be flattish oblique axials on the lower whorls; there may be a subobsolete sculpture of axial ribs crossed by spiral cords; or there may be a few spiral cords only. Both axial and spiral ribs, when present, are low and flatly rounded, and often almost obsolete.) Protoconch small, conical, smooth; whorls almost flat; aperture highly distinctive, perpendicular, subcircular, with a narrow, rather sharp, and often reflected edge, but much thickened internally, no exterior varix; peristome generally continuous, often reflected all round. *Estea.* **Type, *E. zosterophila* (Webster).**

9. Shell thin; sculpture generally absent (when present confined to microscopic spiral grooves); protoconch small, globose, smooth; whorls convex, suture often margined below; aperture subcircular, peristome generally discontinuous, thin and sharp. *Notosetia.* **Type, *N. neozelanica* (Sut.).**

10. Shell moderately thick, pupoidal; sculpture inconspicuous (smooth, spirally lirate, or ridged); protoconch large and globose; whorls slightly convex, elongate; aperture semilunar, extended beyond the body-whorl, peristome duplicated, the inner lip produced forward with a sunken space behind it. *Amphithalamus.* **Type, *A. inclusa* Carp.**

11. Shell rather thin, tall and cylindrical; sculpture obsolete (but strong growth-lines often present); protoconch large and globose, often protuberant, whorls slightly convex, very elongate; aperture similar to that of *Amphithalamus* but narrower and more appressed. *Epigrus.* **Type, *E. ischna* (Tate).**

(B.) "Rissoina" Group.

Aperture semilunar, anteriorly effuse or channelled.

12. Shell solid, elongate, with strong sculpture (generally strong axial riblets crossed by fine spirals, but the latter may be absent); protoconch small, dome-shaped; whorls convex; aperture obliquely oval, channelled below and above, peristome continuous, thickened.
Rissoina. Type, *R. inca* D'Orb.

13. Shell thin, white and highly polished; shell apparently smooth, sculpture very inconspicuous (very fine spiral grooves only, sometimes over the whole surface, sometimes only a few prominent grooves on the base); protoconch minute, flattened; whorls nearly flat; aperture pear-shaped, often truncated below, peristome continuous, outer lip moderately thin, blunt, but reinforced by an external varix.
Nozeba. Type, *N. emarginata* (Hutt.).

14. Shell thin or solid; smooth (rarely with microscopic spiral grooves); protoconch minute, globose; whorls flattened to convex; aperture pyriform or ovate, peristome continuous, hardly thickened.
Dardanula. Type, *D. olivacea* (Hutt.).

(C.) Skenella.

Shell depressed, orbicular, umbilicated.

15. Shell depressed, umbilicated; smooth; protoconch flatly convex, rather large; whorls convex; aperture large, subcircular.
Skenella. Type, *S. georgiana* Pfr.

Of the above genera, *Merelina*, *Onoba*, *Subonoba*, *Anabathron*, *Amphithalamus*, and *Skenella* are as yet unrepresented in the New Zealand Tertiary, while *Haurakia*, *Lironoba*, *Notosetia*, and *Epigrus* are here recorded for the first time. The best-represented genus is *Estea*, with five species; then *Linemera*, with four.

Descriptions of the new species are appended, also notes on the other recorded species; to facilitate identification a key to the fossil genera and species is also appended. The thanks of the author are due to Mr. J. Marwick, of the New Zealand Geological Survey, for the drawing of the figure for *Estea polysulcata*.

Haurakia mixta n. sp. (Fig. 1.)

Shell minute, ovate, axially costate. Protoconch blunt, of about 1½ smooth conical whorls; shell-whorls 2, flattish; body-whorl subangled at periphery, base rounded. About 19 flatly rounded axial ribs on last whorl, interstices generally narrower; ribs pass from suture to suture on spire-whorls but suddenly diminish on reaching periphery of body-whorl and rapidly die out just below it. A strong spiral groove crosses ribs just below suture, but otherwise there is apparently no spiral sculpture in interstices or on base. Spire conical, a little higher than aperture, outlines almost straight. Suture inconspicuous. Aperture squarely ovate, subangled above, flattened below. Peristome nearly continuous, sharp. Columella vertical, subtruncate at base. Imperforate.

Height, 1·2 mm.; diameter, 0·7 mm.; height of aperture, 0·5 mm.

Type, from Castlecliff, in the author's collection.

The species has analogy with *H. hamiltoni* (Sut.) and *H. huttoni* (Sut.), being in some respects intermediate between them. It is probably juvenile, but is distinctly characterized by its flattish whorls, squat form, and infrasutural groove.

Haurakia oamarutica n. sp. (Fig. 2.)

Shell small, oval, imperforate, axially costate. Protoconch of 1½ smooth globose whorls, pullus large. Shell-whorls about 3, convex, body-whorl regularly rounded. Narrow unequally-spaced axial ribs cross whorls, about 30 on body-whorl, fading out on base; interstices generally a little wider than ribs and bearing fine spiral striae. A varix marks outer lip. Both spirals and axials often quite worn off. Spire conical, higher than aperture, outlines almost straight. Suture well impressed. Aperture ovate, angled above. Peristome continuous, slightly thickened, basal lip somewhat expanded. Columella arcuate, hardly expanded. Umbilical area with a small narrow impression.

Type: Height, 1·4 mm.; diameter, 0·8 mm.; height of aperture, 0·5 mm.

Largest paratype: Height, 1·9 mm.; diameter, 1·1 mm.; height of aperture, 0·7 mm.

Type and many paratypes, from Target Gully, in the author's collection.

Very close to *H. huttoni* (Sut.), but separable by its thinner and irregular ribs with spirally-striate interstices, and its constantly much smaller size. The figure shows the shell in a sloping position, hence the spire is somewhat foreshortened.

Linemera n. gen.

Shell superficially similar to *Merelina* i.e., with clathrate sculpture—but protoconch adpressed, smooth, glossy, and dome-shaped, with inconspicuous sutures, instead of being projecting, spirally grooved, dull, and paucispiral, with deep sutures, as in *Merelina.* Apertnre with thin edge, sometimes thickened behind with simple varix, without a second projecting rim inside, rather effuse at base. Chink-like umbilicus generally present.

Type, *L. interrupta* nom. nov. (*Rissoa gradata* Hutt.; Philippi's usage of the same name for an Italian fossil has many years' priority).

Iredale has already indicated the presence of this group in Australian waters (1915, p. 448); here undoubtedly belong *Rissoa filocincta* Hedley and Petterd, *Merelina sculptilis* May, and perhaps *Alvania thouinensis* and *A. suprasculpta*, both of May. The axial sculpture is often reminiscent of *Haurakia,* and a common feature is a slight indentation and a stronger spiral rib near the upper suture. True *Merelina* occurs only in the Recent fauna of New Zealand, and, though like *Linemera* in sculpture, is probably more closely allied to *Anabathron* and *Attenuata*, which have similar lirate embryos. *Rissoa pingue* Webster is the only Recent representative of *Linemera* in New Zealand.

Linemera minuta n. sp. (Fig. 3.)

Shell minute, oval, clathrate, imperforate. Protoconch of 2 globose glossy whorls, nucleus minute, rapidly enlarging. Shell-whorls about 2, indistinctly shouldered just below suture, then flatly convex; body-whorl bluntly angled, base almost flat. Axial sculpture commencing first, consisting of strong bluntly-rounded ribs, sloping forwards and reaching from suture to suture, interstices narrower; they number about 19, and cease just below line of suture on body-whorl. Axials crossed by much weaker spirals, indistinct on early whorls, 4 on penultimate whorl, broad and flatly rounded (interstices sublinear) and cutting up axials into blunt

laterally-elongate tubercles. A fifth spiral emerges from suture-line on to base and is slightly crenulated by ends of axials; below this are 2 smooth and much fainter ribs, the rest of base smooth. Spire a little higher than aperture. Suture much impressed. Aperture slightly oblique, subovate, angled above, effuse below. Peristome discontinuous. Outer lip thin, but does not appear to be finished. Columella slightly oblique, arcuate.

Height, 1·5 mm.; diameter, 0·9 mm.; height of aperture, 0·7 mm.

Type and two paratypes, from Pukeuri, in the author's collection.

Very close to *L. pingue* (Webster). No specimens of this species have been available for comparison, and Webster does not state the number of axials per whorl, but from the description and figure his species would seem to have weaker axials and a rounder body-whorl than the fossil shells. The specimens are not adult, but, in view of the slight differences noted, it is probable that actual comparison of adult shells of the two species would show wider divergence; till then the fossil species is best treated as distinct.

Linemera interrupta (Finlay).

Rissoa gradata Hutt. (not of Phil.).

This species has also considerable analogy with *L. pingue* (Webster), but is characterized by its irregularly-placed spiral ribs, these being crowded anteriorly, but almost absent posteriorly, so that spire-whorls have only two distinct ribs close to suture below. There are, however, traces of faint flattish ribs with linear interstices between these and suture above, and a distinct groove crosses ribs just below suture. *L. filocincta* (H. & P.) is a very similar shell, but has more regular spiral ribs.

Linemera pukeuriensis n. sp. (Fig. 4.)

Shell moderately large for the genus, elongated, clathrately sculptured, rather thin, imperforate. Protoconch of 2 smooth and shining lowly-convex whorls, nucleus minute, swelling rapidly, sharply marked off from the sculptured whorls. Shell-whorls nearly 4, convex, body-whorl regularly and gently rounded. Four thin spirals per whorl, interstices many times their width; spirals equidistant, but a wider concave space between the first one and suture above. Another strong spiral emerges on base from suture-line, and 4 weaker but similar spirals cross remainder of base, the lowest often obsolete. Axials begin at same time as spirals and are narrow, sharp, and distant, interstices variable but about two to three times their width; axials about 18 on body-whorl, very soon dying out below fifth spiral, so that remaining basal spirals are much less crenulated than the others; points of intersection on higher spirals slightly raised into elongated and rather sharp tubercles. Spire about twice height of aperture, outlines nearly straight, but body-whorl turns slightly upwards near aperture which is thus thrown forward basally and axis of shell seems curved. Suture well impressed. Aperture ovate, oblique, projecting basally. Peristome continuous; outer lip with sharp edge but considerably thickened just previously by a strong varix. Columella slightly oblique, arcuate. Inner lip projects prominently as a sharp edge, producing a shallow umbilical chink, surrounded by a very blunt and low basal carina.

Height, 2·5 mm.; diameter, 1·2 mm.; height of aperture, 0·8 mm.

Type and many paratypes, from Pukeuri, in the author's collection. Also from Mount Harris.

This shell has only superficial analogy with the Recent *M. cheilostoma* (Ten.-Woods), though resembling it in appearance.

Linemera awamoaensis n. sp. (Fig. 5.)

Shell small, elongated, finely clathrately sculptured, rather thin, imperforate. Protoconch as in *L. pukeuriensis*. Shell-whorls nearly 3, lowly convex, body-whorl regularly rounded. Six very fine spirals per whorl; uppermost relatively distant from suture above, leaving a concave shoulder between; lowest nearly masked by suture below; interstices several times their width. Four more similar and equally-spaced spirals on base, and sometimes traces of a fifth. Axials commence at same time as spirals, are very fine and numerous, bluntly convex, interstices subequal to them or a little wider. Axials number about 36 on body-whorl, but are less numerous on earliest whorls; they die out just below suture-line on base. Axials stronger than spirals and but little nodulous at points of intersection. Spire about 1½ times height of aperture, outlines faintly convex, body-whorl turning up as in *L. pukeuriensis*. Suture well impressed. Aperture ovate, a little oblique, projecting basally, larger than in *L. pukeuriensis*, and the continuous peristome not so much thickened inside the sharp edge, though an apertural varix is distinct. Columella slightly oblique, arcuate. Inner lip as in *L. pukeuriensis*.

Height, 2·1 mm.; diameter, 1·1 mm.; height of aperture, 0·8 mm.

Type and four paratypes, from Awamoa, in the author's collection.

Easily distinguished from its near relative *M. pukeuriensis* by shorter spire and much finer sculpture.

Lironoba polyvincta n. sp. (Fig. 6.)

Shell small, conical, imperforate, solid, staged. Protoconch of 2 finely but strongly lirate lowly-convex whorls, interstices between lirae linear. Shell-whorls 3, not shouldered, lightly convex, body-whorl regularly rounded. The shell proper, which is abruptly marked off from embryonic whorls, has 5 narrowly-rounded strongly-projecting spiral ribs per whorl, lowest two subequal and strongest, next two weaker, and uppermost one inconspicuous, margining suture above. On later whorls a faint rib margins lower suture, this emerges on base as a rib as strong as upper ones; 3 more equidistant and gradually weakening ribs extend over rest of base. Interstices between ribs about three times their width but become a little narrower on base; they are crossed by regular fine growth-lines, but no dense axial foliations are present. Spire gradate, about 1½ times height of aperture, outlines straight. Suture well impressed, margined below and above. Aperture very little oblique, ovato-polygonal, peristome continuous, much thickened by a strong exterior varix, internally duplicated by small raised rim. Columella arcuate, inner lip raised, but no umbilical chink, encircled by a slight basal ridge.

Height, 2·3 mm.; diameter, 1·2 mm.; height of aperture, 0·9 mm.

Type and several paratypes, from Pukeuri, in the author's collection. Also from Target Gully.

The genus is new as a fossil in New Zealand. It has much narrower and more numerous ribs than the Recent *L. suteri* (Hedley); though the protoconch is spirally lirate, it is here referred to *Lironoba* rather than to

Anabathron, as there is no trace of dense axial foliation, the whorls are not strongly keeled, and the peristome is duplicated in the same manner as in *L. suteri* (Hedley). Target Gully specimens are smaller, slightly more compressed vertically, and the two lowest spirals are more strongly marked on emergence from the protoconch than in Pukeuri shells; but as there are only two examples from Target Gully in the author's collection the slight differences observed may not be constant and hardly justify the creation of even a variety.

Lironoba charassa n. sp. (Fig. 7.)

Shell small, conical, imperforate, solid, staged. Only a small portion of protoconch remains; it has strong spiral ribs with linear interstices, and is sharply marked off from shell proper. Shell-whorls 3, not shouldered, lightly convex, body-whorl regularly rounded. Three moderately-wide flattened strongly-projecting spiral ribs per whorl, lower two subequal and stronger, upper one still fairly strong and margining suture above. On later whorls a faint rib margins lower suture and emerges on base as a rib weaker than other three; four more equidistant and subequal ribs extend over rest of base. Interstices between ribs about twice their width, but narrower on base; they are crossed by regular fine growth-lines. Spire gradate, about 1½ times height of aperture, outlines straight. Suture well impressed, margined above, and, later, below. Aperture very little oblique, more pyriform than polygonal, peristome continuous, much thickened by a strong external varix, internally duplicated by a small raised rim. Columella arcuate, inner lip raised and thickened, distinctly marked off from body-sculpture by a narrow groove, the encircling basal ridge very faint.

Height, 2·5 mm.; diameter, 1·2 mm.: height of aperture, 1 mm.

Holotype (unique), from Nukumaru, in the author's collection.

Very close to preceding species; probably an evolutionary product. From its ancestor it is distinguished by its fewer but thicker ribs, while the Recent *L. suteri* (Hedley) has still fewer. In its aperture, basal sculpture, and apex *L. charassa* is much nearer the Miocene species.

In addition to these last two species, the Australian *L. wilsonensis* G. & G. and a few other forms have spirally-lirate apices; but these shells correspond so closely to other forms with smooth embryos that, though the difference may eventually prove radical, it would seem unwise on present knowledge to make any separation.

Estea polysulcata n. sp. (Fig. 8.)

Shell of moderate size, pupiform, imperforate, solid, with several spiral sulci. Protoconch dome-shaped, of about 2 slightly convex whorls. Shell-whorls about 4½, almost flat, base regularly rounded. Early whorls apparently quite smooth, indications of spiral ribs seen on third whorl, and on following whorls low and flat spiral sulci well developed. On penultimate whorl, between suture and periphery, are about 7 spirals, but the downward turn taken by body-whorl causes about 2 more to be exposed below periphery. About 11 ribs visible on body-whorl, but anteriorly base is smooth. Uppermost spiral margins suture above, and is followed by a wide flat space, then 4 spirals with linear interstices, next 2 spirals separated from each other and from adjacent spirals by shallow grooves as wide as ribs; spaces between the remaining basal spirals linear. In

early whorls periphery is apparently subangled, but becomes convex later; each whorl clasps the one above rather closely but leaves margining sutural cord prominent; these two facts render the suture subcanaliculate. Spire high, about twice height of aperture, outlines pupiform. Aperture ovate, laterally compressed, decidedly oblique. Outer lip broken, but apparently thin and sharp; peristome nearly continuous. Columella very oblique. Inner lip very slightly reflected, spread as a callus over columella and parietal wall.

Height, 3·7 mm.; diameter, 1·4 mm.; height of aperture, 1·2 mm.

Holotype, from Maraekakaho Creek (three miles above junction with Ngaruroro River, Geol. Surv. loc. 1102; horizon Nukumaruian), in the collection of the New Zealand Geological Survey. Collected by Mr. J. Marwick. Also one paratype from Nukumaru, in the author's collection, collected by Mr. R. S. Allan.

Paratype reproduces sculpture of holotype exactly except that second-lowest rib on base is unduly accentuated, forming almost a blunt carina, and faint traces of longitudinal ribs are present. The species is related to *E. semisulcata* (Hutt.), but has far more numerous and more persistent spirals, and a taller and thinner shell; it is still closer to the following species, which, from Hutton's description, seems to be well distinguished by its stronger axial ribs, relatively greater width, and lack of spiral ornament on base.

Estea rugosa (Hutt.).

Only one juvenile specimen of this species has been available for examination, so that it is not generically placed with absolute confidence, but the figure and description seem fairly definitely to indicate this genus. The species combines the types of sculpture shown by *E. impessa* (Hutt.) and *E. polysulcata* Finlay.

Locality: Petane, Nukumaru.

Estea impressa (Hutt.).

Characterized by the stout sloping axial riblets on the lower whorls, the infrasutural groove, and the minute size of the shell. Related to such Australian forms as *E. kershawi* Ten.-Woods.

Localities: Castlecliff, Petane, Waikopiro, Nukumaru.

The Recent *E. minor* (Sut.)—which Suter reduced to a variety of *E. zosterophila* (Webster), but which is certainly worthy of specific rank—is a totally unsculptured relative of this species.

Estea semisulcata (Hutt.).

Distinguished by having about 4 spiral cords, with linear interstices, on the last 1½ whorls only; otherwise very similar to *E. zosterophila* (Webster), to which it bears somewhat the same relation as *E. impressa* does to *E. minor*.

Localities: Castlecliff, Nukumaru.

Estea zosterophila (Webster).

Locality: Castlecliff (*fide* Suter, *Man. Moll.*, p. 211).

This record needs confirmation; it probably is based on a worn *E. impressa* (Hutt.).

Notosetia prisca n. sp. (Fig. 9.)

Shell minute, ovate, body-whorl large in proportion to rest of shell. Sculpture of faint growth-lines; at somewhat regular distances some appear more prominent, but are not raised; a faint furrow emerges from suture on body-whorl and marks periphery. Spire very little higher than aperture. Protoconch of 1½ smooth and polished whorls, marked off by a groove from whorls proper, of which there are 3, lightly convex, body-whorl very slightly subangled for a short distance in front of suture, which is deep and channelled. Aperture oval, oblique, angled above. Peristome discontinuous, outer lip with prominent varix behind, but sharp edge; slightly effuse basally, and angulated medially. Columella short, arcuate, rounded. Inner lip distinctly callous but not covering the narrow elongated umbilical chink.

Height, 1·5 mm.; diameter, 0·9 mm.; height of aperture, 0·7 mm.

Type and several paratypes, from Pourakino, Riverton (Awamoan ?), in the author's collection.

Very close to *N. vulgaris* (Webster); separable only by its consistently smaller size and more tightly clasping spire-whorls. The Recent species has not been found fossil, and it is curious to find a form so closely similar in beds of at least Awamoan age. The outer lip of the holotype is rather more rounded than in the other specimens, most of which have a prominent angulation at about the middle. The holotype, too, on account of its fine preservation, is almost the only specimen that shows the axial markings and median furrow.

Subsp. **paroeca** n. subsp.

Differs from the species only in slightly higher spire and more regularly curved outer lip, which slants downwards from suture without any medial angulation. Both adult specimens show these differences, but otherwise are so like *N. prisca* that full specific rank does not seem justified.

Height, 1·4 mm.; diameter, 0·8 mm.; height of aperture, 0·6 mm.

Type and two paratypes, from Clifden, Southland (bands 6A and 6C Ototaran ?), in the author's collection.

Notosetia sp.

In the author's collection is a single worn specimen of a species from the Kakanui tuffs which somewhat resembles *N. micans* (Webster). Apart from the foregoing species, it is the only one of this genus yet known from pre-Pliocene beds in New Zealand; it is certainly new, but description is withheld till better specimens are obtained.

Notosetia sp. cf. **subflavescens** Iredale.

Rissoa atomus Suter; not of Smith (Iredale, 1915).

Specimens of a shell very close to, if not identical with, this species are not uncommon at Castlecliff; they are rather variable, the body-whorl being often subangled with traces of microscopic spirals on some specimens. They agree with the diagnosis in every point except that of translucent test; opacity may be due to fossilization, but in the absence of authentic specimens of the Recent form identification is deferred. *Notosetia* is the most difficult and unsatisfactory genus in the New Zealand Rissoidae.

The name *Notosetia pupa* nov. is suggested in place of *Rissoa lubrica* Suter, 1898; preoccupied by *R. lubrica* Verrill, 1885.

Epigrus fossilis n. sp. (Fig. 10.)

Shell minute, elongate-oval, smooth and polished. Apex and first whorl lost. Whorls very slightly convex, long in proportion to width, loosely coiled, regularly rounded and not shouldered, base convex. No sculpture except fine flexuous and rather conspicuous growth-lines. Spire elongate-conic, evidently considerably higher than aperture Suture canaliculate. Aperture oblique, ovato-semilunar, extended beyond body-whorl and separated from it by a rather narrow white sunken callosity. Peristome very thick and rounded. Columella short.

Height, at least 1·8 mm.: diameter, 0·75 mm.; height of aperture, 0·7 mm.

Holytype, from Pukeuri, in the author's collection.

The material consists of a single fragmentary specimen, but as the species is evidently rare, and the genus has not previously been recorded from New Zealand, it has been described. The Recent *E. dissimilis* (Wats.) and *E. verconis* (Tate) of Australia seem to be related forms.

Rissoina perplexa n. sp. (Fig. 11.)

Shell minute, rather short, stout, almost imperforate, opaque, but slightly shining. Protoconch of about 2 convex whorls, apex minute, volutions very regular, forming a low but wide dome, sharply marked off from shell proper. Three post-embryonic convex whorls, base regularly rounded. Distant broadly-convex axial ribs cross whorls from suture to suture, 11 on body-whorl, faint at extremities, but gradually swelling at middle of whorls; they rapidly diminish in strength near periphery and are absent on base, which is quite smooth; interstices are 2–3 times width of ribs. Spiral sculpture absent except for faint swelling margining suture above, and fairly strong, blunt angulation at upper three-quarters of whorls; between these is a small concave shoulder. Spire bluntly conical, about 1½ times height of aperture, outlines lightly convex. Suture impressed, submargined below. Aperture suboval, oblique, both from left to right and from front to back, projecting farthest anteriorly. Peristome complete, sharp, but considerably thickened on upper part of outer lip, though not much elsewhere. A strong basal channel, marked by a semicircular curve in peristome; also a distinct posterior notch in outer lip. Inner lip not much thickened, encircled by a tiny umbilical chink.

Height, 2·1 mm.; diameter, 1 mm.; height of aperture, 0·8 mm.

Holotype (unique), from Clifden, Southland (horizon 6, of Park*), in the author's collection.

The channelled basal lip seems to indicate that this species is a *Rissoina*, otherwise it has considerable superficial resemblance to *Haurakia*. It is much smaller than any of the Recent species, and the aperture, too, is not quite in accord, being perhaps most like that of *R. chathamensis* (Hutt.), but the basal channel is less lateral; however, a somewhat similar type of notch is shown by *Nozeba*. *Rissoa nana* (Lamk.), and especially *R. misera* Desh., from the Paris Basin (Bartonian and Cuisian respectively) have considerable likeness to the new species, but it cannot be said from figures alone if they are generically related. It is a question, however, whether Iredale's "Gordian-knot solution" of abandoning almost all northern genera in favour of new austral ones will not rather hinder than help when Tertiary

* J. PARK, Geology and Mineral Resources of Western Southland, *N.Z. Geol. Surv. Bull. No. 23* (n.s.), p. 52, 1921.

species are under consideration. The convenient excuse that "the particular forms that conchologically agree are known, in the few cases that animal or opercular features have been studied, to disagree" is unfortunately not available for the palaeontologist, and it will not be the easiest of matters to decide at what stage of the Tertiary the line of separation should be drawn.

Rissoina chathamensis (Hutt.).

R. rugulosa (Hutt.) (see Iredale, *loc. cit.*, p. 453).

Locality: Castlecliff.

Rissoina (?) **obliquecostata** M. & M.

This shell is, as its describers remark, "very different from any other of our Recent or fossil Rissoids." It does not look adult, though this cannot well be judged from a figure, and is quite probably not a member of this family at all. The "narrow subperforation at the side of the columella, bounded by a small funicular ridge which curves round to the basal lip," is not reminiscent of any Rissoid.

Locality: Hampden.

Nozeba candida n. sp. (Fig. 12.)

Rissoina emarginata (Hutt.): Suter, *N.Z. Geol. Surv. Pal. Bull. No. 8*, p. 82 (not of Hutt.).

Shell small, trapezoidal, imperforate, polished, milk-white, loosely coiled, base truncate, with a few spirals. Protoconch minute, smooth, and shining, subhelicoid, nucleus globular. Shell-whorls 5, flatly convex, very glossy, the last large, occupying about three-quarters total height, slightly flattened below suture. Shell at first sight smooth, but close examination shows traces of linear spiral grooves on whorls, more distinct on upper ones just below suture; one or sometimes two on periphery, rather more prominent, those on base much more prominent; these vary in number from 4 to about 7, fairly equally spaced, but those near columella closer and fainter. A very shallow sulcus runs parallel with suture just below it, giving it an indistinctly margined appearance. Suture distinct but not impressed, also very faintly submargined above. Spire conical, not much higher than aperture. Aperture subvertical, subtriangular, the almost flat basal margin extending nearly whole width of aperture, outer lip descending to meet it in a gentle curve, union of the two much produced outwards. A strong lowly-convex and rather wide varix encircles outer lip, which has a bluntly-rounded edge. Peristome continuous, of irregular shape, heavily calloused along parietal wall; a narrow posterior channel in aperture, basal lip somewhat effuse and hollowed out, forming a very wide indistinct canal. Columella oblique, covered by the well-marked callus of inner lip, meeting basal lip in a bluntly rounded acute angle.

Height, 2·7 mm.; diameter, 1·4 mm.; height of aperture, 1·2 mm.

Type and many paratypes, from Pukeuri, in the author's collection. Also found at Ardgowan and Target Gully.

This shell has previously been recorded in lists from Awamoan localities as *Rissoina emarginata* (Hutt.). It is easily distinguished from this Recent and Pliocene species by the absence of the regular close grooves and the

differently shaped aperture. In the prominence of the basal grooves and almost smooth whorls it resembles *N. coulthardi* (Webster), but differs in its aperture. It is perhaps ancestral to these two Recent species. In the type specimen figured the basal margin is not so long and flat as in most specimens.

Var. **effusa** n. var.

Differs from the species only in its aperture, which is more effuse and projecting below and lacks the strong angulation at junction of basal and outer lips. This variety makes a still nearer approach to *N. coulthardi* (Webster), but the aperture remains a little truncate below, basal lip meeting columella in an acute angle as in the species.

Holotype and one paratype, from Pukeuri, in the author's collection.

Dardanula olivacea (Hutt.).

A rather solid, totally smooth shell, with flattish whorls.

Localities: Castlecliff, Nukumaru.

Dardanula rivertonensis n. sp. (Fig. 13.)

Shell minute, elongate oval, smooth. Protoconch obtusely marked off, blunt, of about 2 smooth flatly-convex whorls. Whorls about 5, flat, periphery bluntly angled. Surface quite smooth. Suture rather well impressed, especially in later whorls; body-whorl takes a downward curve near aperture, and becomes a little separated from penultimate whorl, so that suture becomes much deeper anteriorly. Spire conical, nearly twice height of aperture, which is subcircular, oblique, angled above. Peristome not quite continuous, but ends united by parietal callus. Columella short, arcuate, callous.

Height, 2 mm.; diameter, 1 mm.; height of aperture, 0·7 mm.

Holotype and many paratypes, from Pourakino, Riverton (horizon probably near Awamoan), in the author's collection.

Closely related to *D. olivacea* (Hutt.) and *D. limbata* (Hutt.), but smaller more slender, and with the aperture more oblique (both from left to right and from front to back) and relatively smaller. This is the only pre-Pliocene *Dardanula*. It is interesting that a form so close to the Recent species should be abundant in a locality of this age, when up till now it has been found nowhere else. The type and a few other specimens show traces of zigzag colour-bands most prominent on the periphery, as in the Recent shells.

Rissoa vana Hutt.

This name must be omitted from Rissoid lists, as it is a synonym of *Potamopyrgus badia* Gould. The specimens clearly came not from the Miocene clays at Awamoa, but from the Holocene river-gravels overlying these. Every flood of the Awamoa Stream lays a fresh coating of silt over the exposed parts of the beds, and, as *Melanopsis, Isidora, Lymnoea, Sphaerium,* and species of *Potamopyrgus* (especially *P. badia*) are plentiful in the stream, it is only to be expected that these should be found, as they all are, in a subfossil condition in the surface soils. The occurrence with them of numerous small land-shells is further proof of this origin; also, all these specimens are in a different state of preservation from the true Miocene

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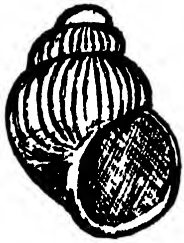

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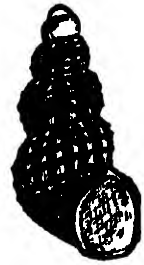

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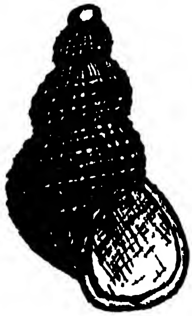

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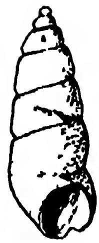

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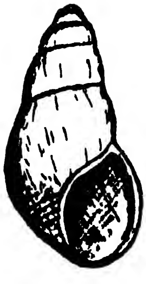

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FIG. 1.—*Haurakia mixta* n. sp. × 30.
FIG. 2.—*Haurakia oamarutica* n. sp. × 30.
FIG. 3.—*Linemera minuta* n. sp. × 18.
FIG. 4.—*Linemera pukeuriensis* n. sp. × 14.
FIG. 5.—*Linemera awamoaensis* n. sp. × 20.
FIG. 6.—*Lironoba polyvincta* n. sp. × 12.
FIG. 7.—*Lironoba charassa* n. sp. × 12.
FIG. 8.—*Estea polysulcata* n. sp. × 8.
FIG. 9.—*Notosetia prisca* n. sp. × 20.
FIG. 10.—*Epigrus fossilis* n. sp. × 19.
FIG. 11.—*Rissoina perplexa* n. sp. × 19.
FIG. 12.—*Nozeba candida* n. sp. × 12.
FIG. 13.—*Dardanula rivertonensis* n. sp. × 14.

species, and frequently retain their colour-bands. One or two juvenile shells in the author's collection, which had been doubtfully named "*R. vana* Hutt.," proved to have exactly the same protoconch as specimens of *P. badia* gathered both living from the stream itself and subfossil from the silt. Suspicion of the identity of the two species was confirmed by examination of the type (kindly lent, through Mr. Marwick, by Miss Mestayer), so that the name *R. vana* Hutt. must be dismissed from faunal lists. *Potamopyrgus speleus* (Frauenfeld) has been found by the author in exactly similar circumstances, occurring with Pliocene fossils from Castlecliff.

Key to Genera.

Aperture suboval, edge thin, often reflected, much thickened internally, no exterior varix	*Estea.*
Aperture with the edge either thin or thickened by means of an external varix.	
(1.) Very strong spiral-cords	*Lironoba.*
(2.) Clathrate sculpture.	
(A.) Protoconch spirally lirate, dull	*Merelina.*
(B.) Protoconch smooth, glossy	*Linemera.*
(3.) Axial ribs most prominent.	
(A.) Aperture rotund, simple; spirals rarely present ..	*Haurakia.*
(B.) Aperture obliquely ovate, channelled below, spirals generally present	*Rissoina.*
(4.) Surface almost smooth.	
(A.) Shell white, highly polished, aperture channelled below ..	*Nozeba.*
(B.) Shell white, smooth, tall and cylindrical, aperture separated from the body-whorl by a groove	*Epigrus.*
(C.) Shell smooth or faintly spirally lirate, whorls convex, aperture simple, rotund	*Notosetia.*
(D.) Shell smooth, whorls flattish or convex, aperture ovato-pyriform, slightly channelled below..	*Dardanula.*

Key to Species.

Genus *Haurakia.*

1. About 20 axial ribs per whorl, with an infrasutural groove, whorls flattish	*H. mixta* Finlay.
2. About 30 axial ribs per whorl, with faint spirals between, whorls convex	*H. oamarutica* Finlay.

Genus *Linemera.*

1. Two distinct spiral ribs close to the lower suture, with a smooth band between, also an infrasutural groove ..	*L. interrupta* Finlay.
2. Four weak and broad spirals per whorl, interstices linear	*L. minuta* Finlay.
3. Four distinct but thin spirals per whorl, interstices much wider; axials about 18 per whorl	*L. pukeuriensis* Finlay.
4. Six very fine spirals per whorl, interstices much wider; axials about 36 per whorl	*L. awamouensis* Finlay.

Genus *Lironoba.*

1. Five spiral ribs per whorl, with 4 more on the base, interstices about three times their width	*L. polyvincta* Finlay.
2. Three spiral ribs per whorl, with 5 more on base, interstices about twice their width	*L. charassa* Finlay.

Genus *Estea.*

1. Shell without sculpture	*E. zosterophila* (Webster).
2. Shell with spiral sculpture only.	
(*a.*) Five spiral cords with linear interstices on the last 1½ whorls	*E. semisulcata* (Hutt.).
(*b.*) Seven spiral cords on the last 2 whorls, about 11 on base	*E. polysulcata* Finlay.
3. Shell with axial riblets, about 20 per whorl, interstices narrower, and an infrasutural groove ..	*E. impressa* (Hutt.).
4. Shell with subobsolete axials, about 22 per whorl, and 5 spirals on the spire-whorls, 3 more on base ..	*E. rugosa* (Hutt.).

Genus *Notosetia.*

1. Aperture pear-shaped, spire noticeably higher than aperture	*N.* cf. *subflavescens* Iredale.
2. Aperture subcircular, spire almost equal to aperture ..	*N. paroeca* Finlay.
3. Aperture subrhomboidal, spire subequal to aperture but rather immersed, last whorl very large	*N. prisca* Finlay.

Genus *Epigrus.*

1. Shell with elongate spire and regularly flatly convex whorls and deeply channelled suture	*E. fossilis* Finlay.

Genus *Rissoina.*

1. Shell elongate, about 16 axials per whorl	*R. chathamensis* (Hutt.).
2. Shell oval, about 30 axials per whorl	*R. obliquecostata* M. & M.
3. Shell minute, short, about 11 axials per whorl	*R. perplexa* Finlay.

Genus *Nozeba.*

1. Spiral grooves present over the whole surface, aperture pyriform, truncated	*N. emarginata* (Hutt.).
2. A few prominent spiral grooves on base only, aperture subtriangular, very broadly truncated	*N. candida* Finlay.
3. Ditto, but aperture effuse and produced	*N. candida* var. *effusa* Finlay.

Genus *Dardanula.*

1. Height of shell about 1½ times the width, shell reaching a height of 3 mm.	*D. olivacea* (Hutt.).
2. Height of shell about twice the width, shell reaching a height of 2 mm.	*D. rivertonensis* Finlay.

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The Molluscan Fauna of Target Gully: Part 1.

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CONTENTS.

SINCE Target Gully is the richest fossil deposit in New Zealand, and in many ways is regarded as a type locality for the Awamoan horizon, it is necessary that its fauna should be thoroughly examined. Five visits have been paid to Oamaru localities, and some forty to fifty thousand specimens have been obtained. Examination of these has shown that the existing list of fossil shells from this locality (13*a*)* is far from complete, and needs much revision in its nomenclature. The present paper is a preliminary attempt to deal with this: it consists of lists of new records from four Oamaru localities, and a series of notes on the necessary nomenclatural changes. A complete list of the Mollusca from Target Gully will be presented on a future occasion.

The following species, not previously obtained from this locality, may now be added to the list. Where a name has been corrected, the old name is placed in square brackets after it. To facilitate reference the lists are in alphabetical order. An asterisk denotes a Recent species. Probably it will prove, when actual specimens have been compared, that the "Recent" species in these and other lists are not in all cases conspecific with now-living forms, but for the present these names are in usage and can be adopted as tentative.

Aethocola spinifera Finlay and McDowall.
Alectrion latecostata Sut.
Bela tenuilirata (Sut.). [*Ptychatractus.*]
**Cadulus delicatulus* Sut. (Recorded as fossil previously only from Pakaurangi Point.)
Callanaitis speighti Sut. [*Chione.*]
Chlamys chathamensis (Hutt.). [*Pecten.*]
Cominella pulchra Sut.
Crossea cf. *cancellata* (T.-Woods). (New as a fossil.)
Cucullaea alta var. B Hutt.
Cucullaea attenuata Hutt.
Galeodea senex (Hutt.).
**Hexaplex octogonus* var. *umbilicatus* (T.-Woods). [*Murex.*]
**Hexaplex octogonus* var. *espinosus* (Hutt.). [*Murex.*]

* Numbers in brackets refer to the bibliography at the end of the paper.

**Lepidopleurus iredalei* Ashby. [*L. inquinatus.*] (New to the Miocene, and the first Chiton recorded from the Awamoan.)
**Murex zelandicus* Q. & G.
**Nuculana bellula* (A. Ad.). [*Leda.*]
Ostrea wuellerstorfi Zitt. (A juvenile shell, but apparently referable to this species.)
Pecten beethami Hutt.
Pecten hutchinsoni Hutt.
**Pleurodon maorianus* Hedley. (Previously recorded fossil only from Pukeuri.)
**Saxicava arctica* (L.). (New for the Miocene.)
Sinum miocaenicum (Sut.).
Struthiolaria subspinosa Marwick.
Struthiolaria tuberculata Hutt.
Typhis maccoyi T.-Woods.
Vexillum fenestratum Sut. (Also at the Rifle Butts.)
Vexillum linctum (Hutt.).

In addition, various authors have recorded the following species from Target Gully:—

Admete suteri Marsh. & Murd (8*b*, p. 132).
Admete maorium Marsh. & Murd. (8*c*, p. 82).
Aethocola spinifera Finlay and McDowall (3, p. 113).
Austrotriton neozelanica Marsh. & Murd. (8*d*, p. 122).
Calliostoma suteri Finlay (2*a*, p. 101).
Calliostoma suteri var. *fragile* Finlay (2*a*, p. 102).
Couthouyia concinna Marsh. & Murd. (8*c*, p. 80).
Drillia laevis Hutt. (8*a*, p. 249).
Eulima aoteaensis Marsh. & Murd. (8*c*, p. 84).
Euthria subcallimorpha Marsh. & Murd. (8*c*, p. 83).
Ficus subtransennus Marsh. & Murd. (8*a*, p. 249).
Ficus imperfectus Marsh. & Murd. (8*a*, p. 255).
Melina zelandica Suter (8c, p. 77).
Odostomia pseudorugata Marsh. & Murd. (8*c*, p. 83).
Venericardia bollonsi Suter (8*a*, p. 249).
Vermicularia ophiodes Marsh. & Murd. (8*c*, p. 80).

Notes on *Admete*, *Austrotriton*, *Euthria*, and *Odostomia* will be found later on in this paper. The record of *Melina zelandica* Sut. is here confirmed (though the name should be *Isognomon zelandicum* (Sut.), *Isognomon* Solander, 1786, having two years' priority over *Melina* Retzius, 1788—see 6*b*, p. 303); but the identification of *Drillia laevis* Hutt. is probably erroneous. The name *Ficus subtransennus* is possibly a *lapsus calami* for *F. transennus* Sut.; if not, it is a *nomen nudum*, as no such shell has been described or figured.

Of the remaining species, *Admete suteri* and *A. maorium* are two of the shells termed "*Merica* n. spp." by Suter in the list of 1916; *Calliostoma suteri* is his "*Calliostoma* n. sp.," and its variety *fragile* is his "*Basilissa* n. sp."; *Eulima aoteaensis* is his "*Eulima* n. sp."; *Odostomia pseudorugata* is one of his "*Odostomia*, 2 n. sp."; and *Vermicularia ophiodes* is his "*Vermicularia* sp."

Suter's "*Merica* (*Aphera*) n. sp." is a juvenile shell of *Latirus brevirostris* (Hutt.). This species is undoubtedly a Cancellarid, and, though not quite typical, agrees fairly well with *Bivetia* as defined by Cossmann. A true (undescribed) species of *Aphera* does, however, occur at Target Gully. Suter's "*Sveltia* n. sp." is probably a *Vexillum* (*Fusimitra*) n. sp.

As regards the "*Barnea* n. sp." of the list, there is considerable doubt. I have a small indeterminable fragment of a shell that may belong to this species, and perhaps this was the species Suter referred to; but in the collection of the Otago School of Mines is another shell which is so labelled in Suter's writing, and which is only a much-twisted left valve of *Anomia trigonopsis* Hutt., with the scars and ornamentation quite distinct.

An examination of specimens from Target Gully of *Modiolus australis* (Gray) and *Monodonta coracina* (Troschel) is desirable, as these records are very doubtful. I have already shown (2*a*) that the record of *Trochus tiaratus* Q. & G. is almost certainly erroneous.

As regards the nomenclature of the recorded species, many changes are necessary, for the work of Iredale, Hedley, and others has shown that the old common names are often wrongly used. Most of the corrections to be made in the present list are contained in the "Commentary" published by Iredale in 1915 (6*a*). Others are contained in papers contributed by the same author to the *Proc. Mal. Soc.* (6 *b, c, d*); several changes have been made by Hedley in various publications (4 *a, b*); some corrections were suggested in these *Transactions* by Cossmann (1); and I have advocated various nomenclatural changes (2*b*). The following are the necessary changes as regards names of Target Gully shells:—

Calyptraea maculata (Q. & G.) should be *C. novae-zelandiae* (Lesson) (6*a*)

Chamostraea and *Cytherea* should respectively be *Cleidothaerus* (1) and *Antigona* (6*a*).

Circulus helicoides (Hutt.) and *C. politus* Sut. are congeneric with the Recent *C. subtatei* Sut. of New Zealand and *C. tatei* (Angas) of Australia, which is the type of Iredale's genus *Elachorbis* (6*a*), so that here *Circulus* must give place to his genus-name. *Circulus cingulatus* Bartrum (7), from Kaawa Creek, is another member of this genus.

Leda should be *Nuculana* (6*a*), and *Lissospira exigua* Sut., which is congeneric with *L. micra* (T.-Woods), should be classed with it as a *Lissotesta* (6*a*).

Of the three Pectens listed, two belong to the genus *Chlamys* (6*a*) namely, *burnetti* Zitt. and *radiatus* Hutt.

The name *Cyclostrema* must disappear from the list. There are many minute species from Target Gully that fall very well into the genera of Iredale's family *Liotiidae* (6*a*), but *Cyclostrema*, as Iredale has shown, is indeterminable, being too indefinitely characterized.

Cossmann, after examining specimens of *Cylichnella soror* Sut. and *C. enysi* Hutt., pronounced them both to belong to *Bullinella* (1). The same author states that *Leptothyra fluctuata* (Hutt.) is a *Tiburnus* (1), but Iredale has named this species as the type of his genus *Argalista* (6*a*), and, unless it is shown that the two are identical, this is the genus-name it will bear. Iredale mentions (6*a*) that *Leptothyra laeta* Montrouzor, *L. picta* Pease, and *Pseudoliotia imperforata* Sut. are congeneric, and adopts the name *Leptothyra* (6*a*) for all; but later (6*d*) he has shown that *Leptothyra* was proposed for a different kind of shell, and has introduced the name *Collonista* for these species, with *C. picta* (Pease) as type. *Collonista imperforata* (Sut.) has not yet been found fossil.

Loripes, *Psammobia*, and *Tellina glabrella* Desh. should respectively be *Lucinida* (6*a*), *Gari* (6*a*), and *Macoma edgari* Iredale (6*a*).

Murex angasi Crosse falls into the genus *Pteronotus* (6*a*), while *M. octogonus* Q. & G. is placed by Iredale in Perry's genus *Hexaplex* (6*a*). *Trochus chathamensis* (Hutt.) is the type of *Thoristella* Iredale (6*a*), but the shell so called from Target Gully is distinguishable by its umbilical characters from Recent specimens, and will be described later. All the Target Gully

Trophons are members of Iredale's genus *Xymene* (6*a*), being congeneric with *X. plebejus* (Hutt.), the type of this genus.

Odostomia has been divided generically by Iredale (6*a*): *O. pudica* Sut remains in *Odostomia*, but *O. rugata* Hutt. should be *Pyrgulina rugata* (Hutt.), and *O. pseudorugata* M. & M. should accompany it here.

Surcula, *Tornatina*, *Tritonidea*, and *Volvulella* should respectively be *Turricula* (6c), *Retusa* (6*b*), *Pollia* (6*a*), and *Rhizorus* (6*b*).

Suter's usage of the name *Hemiconus ornatus* (Hutt.) being illegal (2*b*), its place must be taken by *H. trailli* (Hutt.).*

Venericardia pseutes Sut. should be *V. awamoaensis* Harris (2*b*), and the record of *V. difficilis* (Desh.) should be expunged, being based on juveniles of the shell listed as *V. subintermedia* Sut. n. var.

The shell identified as *Cantharidus tenebrosus* A. Ad. is not that species, but a new one, closer to *C. sanguineus* Gray.

The type of *Crepidula striata* (Hutt.) is lost, and the species indeterminable; the shells classed under that name should be *C. radiata* (Hutt.) (2*b*) - Hutton's *Pilaeopsis radiatus*. The forms recorded as *C. costata* (Sow.) belong in some cases to *C. radiata* (Hutt.), in others to a species easily separable from the Recent *C. costata* (Sow.), and this name should be omitted. *C. incurva* Zitt. (which is not identical with *C. gregaria* Sow.) is preoccupied, and has been renamed *C. wilckensi* Finlay (2*b*).

The record of *Xymene quirindus* Iredale (Suter's *Trophon hanleyi* Ang.) refers to a variant of *X. lepidus* (Sut.), which is plentiful at Target Gully, and varies considerably in size, shape, and ornament, though it is fairly constant at Ardgowan. I have found no specimen of *X. quirindus* in the Miocene, so that the record of this Recent species had better be omitted from Target Gully lists until authentic specimens are found. It may be mentioned here that *Cymatium suteri* M. & M. (8*c*, p. 80) is evidently a *Xymene*, quite close to *X. lepidus* (Sut.) and other new Awamoan species.

Limopsis catenata Sut., described as a new species from Target Gully, is the juvenile form of *L. zitteli* Iher., common at that locality.

Mitra armorica Sut. does not occur at Target Gully, the form found there differing markedly from Otiake and Blue Cliffs specimens.

Rissoina emarginata (Hutt.) is included in the list, being given as new for the Miocene. This record is based on a shell not very common at Target Gully, but plentiful at Pukeuri. Good specimens from the latter locality are easily obtained, and show that the species, though closely related to *Nozeba emarginata* (Hutt.) (6*a*), is certainly distinct, presenting characters intermediate between *N. emarginata* (Hutt.) and *N. coulthardi* (Webster), being probably the ancestral form from which these Recent species diverged.

Similarly, the Recent *Fusinus spiralis* (A. Ad.) is not a member of the Target Gully fauna, the species occurring there being referable to *F. dentatus* (Hutt.), which should not be treated merely as a subspecies of *F. spiralis*. The occurrence of *F. climacotus* Sut. is doubtful.

Mr. Marwick is of the opinion that *Cardium patulum* Hutt. and *Protocardia alata* Sut. should be united under the name *Protocardia patula* (Hutt.). It seems probable that *Protocardia sera* Hutt. is also a synonym; topotypes in my collection seem indistinguishable from *P. patula*. At all events, only the latter species should be admitted to the lists from the Awamoan localities here discussed.

* Since treating of this species (2*b*) I have discovered that the name *Conus traillí* is also preoccupied, by A. Adams (*Proc. Zool. Soc.*, 1855, p. 121). I now propose for the New Zealand Tertiary species the name *Oenopota bimutata* nom. nov. The shell disagrees radically with *Hemiconus*, and is best left where Suter originally placed it.

The record of *Cymatium minimum* (Hutt.) should be erased from all Awamoan lists, and probably from most others, the type of that species (which has been found by Mr. Marwick, and which, through his courtesy, I have examined) having a tall, slender spire, and in sculpture and appearance differing altogether from the form which is common at most Awamoan horizons, and which really represents a new species of *Austrotriton*, very closely related to the Recent *A. parkinsonianum* (Perry). The shell described from Target Gully by Marshall and Murdoch as *A. neozelanica* seems to have little in common with that genus, and is more fittingly placed in *Charonia;* a new species I have from Clifden, Southland, is closely related and is undoubtedly a *Charonia.*

Turris regius Sut. and *Borsonia rudis* (Hutt.) are characteristic Waiarekan species, and really occur, as far as is yet known, only in the Waihao greensands. Nothing like them occurs at Target Gully, and both these records should be expunged. The existing records of *Borsonia* from the Awamoan (and often other horizons) are mostly based on fractured examples of Suter's *Ptychatractus pukeuriensis* or allied species (which are discussed later). I have not yet seen any example of a true *Borsonia* from the Awamoan.

Corbula canaliculata Hutt. and *C. humerosa* Hutt. are listed as separate species, but are really opposite valves of the same species. All the specimens of *C. canaliculata* that I have, from many Oamaru localities, are right valves, and all of *C. humerosa* are left valves; all my double-valved shells are *humerosa* on one side and *canaliculata* on the other. The two forms always occur together. Suter, when examining the type of *C. humerosa,* mistook the ligament process for a cardinal tooth, and the dental socket for a resiliary pit; he accordingly described it as a right valve, but from the sculpture and his figure it is undoubtedly a left valve. The type of *C. canaliculata* is from Mount Harris, and that of *C. humerosa* from White Rock River; these horizons are both Awamoan and approximately coeval, so that when the above remarks are borne in view any doubt as to their representing the same species disappears. The specific name *humerosa* has two years' priority, and should be used to cover all these forms.

The shells classed in *Bela*, *Ptychatractus*, and *Borsonia* by Suter are unsatisfactorily placed in several cases, but their true position is very difficult to determine. *Ptychatractus tenuiliratus* Sut., *Bela infelix* Sut., and *B. canaliculata* Sut., whatever their true location may be, are undoubtedly congeneric, agreeing in details of general shape and ornament, conoidal, many-whorled protoconch, columellar plications, and distinct rounded sinus close to the suture. Cossmann has referred *B. canaliculata* Sut. to *Ptychatractus* (1) in the family Fusidae, but the sinus shows that these shells are Turrids: possibly the shell Cossmann studied was wrongly labelled. Suter's location in *Bela* auct.—for which, by the way, Iredale has advocated the substitute *Oenopota* (6a)—is also unhappy, as this genus has a different protoconch, and no columellar folds Tate (14) has referred what seems to be an essentially similar shell to *Cordieria*, and compared the Australian *C. conospira* Tate with the Paris Basin *C. marginata* Desh. and *C. turbinelloides* Desh., but these have quite different columellar plaits, and are much more like some New Zealand species of *Borsonia* from the Waihao greensands. Tate's species agrees very well with *P. tenuiliratus* Sut. in sculpture, apex, and plaits, but is more slender. More recently, May (10) has figured *Daphnella columbelloides* T.-Woods, which he places in *Buchozia*, and this shell seems still closer to the Neozelanic *P. tenuiliratus* Sut. Evidently a homogeneous group of species is represented by these shells, and their peculiar nature will probably

demand the creation of a new genus. This will be attended to in a revision of the New Zealand Turridae; in the meantime they may be left temporarily in *Bela*. In connection with this note it may be mentioned that *Daphnella varicostata* M. & M., recently described from the beds at Awamoa, is a synonym of *B. canaliculata* Sut. The figure does not show the important columellar plaits, and the sutures are more sloping than usual, but both these differences (as also those mentioned regarding sculpture, protoconch, and suture) can be matched by specimens in my collection from Pukeuri and Target Gully. It is very unusual for the plaits to be obsolete, but two of my senile specimens have an almost smooth pillar. Probably if the specimens used by Marshall and Murdoch were examined they would show this generic feature; it is to be noted that the diagnosis contains the words "columella . . . with small oblique threadlets corresponding with the adjacent spirals," so that these are probably not restricted to the parietal wall as in the figure. In all other respects their shell is a typical senile *B. canaliculata*.

On the other hand, Suter's remaining species of *Ptychatractus* namely, *P. nodosoliratus* and *P. pukeuriensis*—are certainly not congeneric. Cossmann places the former in *Bela* (Buchozia) (1), but it is very doubtful if the shells he examined were really *P. nodosoliratus* Sut. The parcels sent to this eminent authority seem to have been somewhat carelessly packed, as there are several cases where confusion of species seems to be the only explanation that will account for the remarks made on them *e.g.*, *Limopsis aurita*, *Bela canaliculata*, and the species at present under consideration. It seems very probable that the last two species were interchanged, for Cossmann's generic reference in each case seems to apply better to the other species, though even then still apparently incorrect. *P. nodosoliratus* is really a Turrid, and it and other congeneric species (including *Borsonia brachyspira* Sut. and *Antimitra vexilliformis* M. & M. will be dealt with in an account of this family; at present it may be left in *Ptychatractus*.

P. pukeuriensis Sut., however, has little in common with either Fusidae or Turridae, and shows far more analogy with some sections of the Cancellaridae. So far as can be judged from figures and descriptions, it is congeneric with the Australian shells placed by Harris in *Narona*, which, however, has a much longer aperture and a canal. The characteristically curved columella of *Bonellitia* is completely absent, and the shells bear no resemblance to true New Zealand members of this genus, such as *B. hampdenensis* M. & M. Cossmann mentions a deep sinus at the extremity of the anterior canal as an attribute of *Narona;* this is not present in *P. pukeuriensis* Sut., but some of the Australian species show no sinus; in general aspect, detail of ornamentation, columellar plaits, shape of aperture and canal, lirate outer lip, and bluntly conical protoconch, slightly askew posteriorly, and with longitudinal plications anteriorly, *P. pukeuriensis* agrees exactly with the Australian *Narona* group, more especially *N. etheridgei* (Johnston), and to a less extent *N. caperata* (Tate). Cossmann, in the *Essais*, vol. 3, has referred the former of these doubtfully to *Brocchinia*, and, apart from this genus, the only other to which these shells bear much resemblance is *Sveltella*. As regards the Australian species of this family, both the classification given by Tate in the "Census" (*loc. cit.*) and that of Cossmann above referred to seem unsatisfactory and inconsistent, but it would be a difficult task to draw up a correct one; the New Zealand species, too, are not easy to place, and the correct generic position of *P. pukeuriensis* Sut. and other species must be left in doubt till the family can be revised. In the meantime, however, since *Ptychatractus*

is quite inadmissible, Cossmann's choice of *Brocchina* seems to be the least discordant, and the name *Brocchina pukeuriensis* (Sut.) may be used till some more suitable alternative is found. *Admete anomala* M. & M. from Hampden is possibly another congeneric species, while "*Borsonia*" *cincta* (Hutt.) certainly is, and is doubtfully separable specifically. It has already been mentioned that members of this group are responsible for most of Suter's records of *Borsonia* spp. It may also be mentioned that *Admete suteri* M. & M. is evidently the Neozelanic representative of such Australian Tertiary forms as *Cancellaria ptychotropis* Tate and *C. gradata* Tate, which have been variously placed in *Bivetia* and *Aneurystoma*, but both these locations seem unhappy; *Plesiocerithium* seems nearer, but the Neozelanic shell had better remain in *Admete* until the family is revised. *Bivetia* (?) *brevirostris* (Hutt.) is the New Zealand representative of *C. modestina* Tate, but the relation is not very close. *Admete maorium* M. & M. is possibly a *Sveltella*, but may be left in *Admete* at present. Of the other New Zealand members of this family, *Admete ambigua* Hutt. is probably an *Actaeon*, and *A. lacunosa* Hutt. is a *Bonellitia*. A summary, therefore, of the Target Gully members of this family reads,

Admete (?) *maorium* M. & M.
Admete (?) *suteri* (M. & M.).
Bivetia (?) *brevirostris* (Hutt.).
Brocchina pukeuriensis (Sut.).

The name *Siphonalia* cannot be retained. Iredale has proposed the name *Verconella* (6a) for the forms with large embryos, strong spiral sculpture, and generally rounded whorls, while he puts *S. nodosa* (Martyn) in the subgenus *Aethocola*. There are many fossil species in our Tertiary that must be placed with *S. nodosa* (Martyn), and in Mr. Marwick's opinion *Aethocola*, which has a deep sinus at the extremity of the anterior canal, must be treated as a full genus and removed to the family Buccinidae, while *Siphonalia* (which is a Japanese genus and has no representative in New Zealand) and *Verconella* belong to the family Chrysodomidae. Of the list species, *S. costata* (Hutt.), *S. conoidea* (Zitt.), and *S. nodosa zitteli* Sut. belong to *Aethocola*, while *S. caudata* (Q. & G.), *S. dilata* (Q. & G.), *S. excelsa* Sut., and *S. subreflexa* (Sow.) fall under *Verconella*.

Extensive alterations are necessary in the specific names, as follows: Hedley (4a) has shown that the shell called *Megalatractus maximus* (Tyron) is almost certainly the true *Verconella dilatata* of Quoy and Gaimard, while the species usually called *Siphonalia dilatata* must bear the name *Verconella adusta* (Phil.). The matter does not end here; for neither of the Recent species *V. dilatata* (Q. & G.) and *V. adusta* (Phil.) really occur in Awamoan horizons, the records referring to new species of *Verconella*, so that these two names must be expunged from Oamaru lists.

Again, *V. caudata* (Q. & G.) does not occur at Target Gully, nor in the Awamoan at all, the record in this case apparently referring to extremes of the variable species Suter has named *Tritonidea compacta*. Similarly, *V. subreflexa* (Sow.) is wrongly recorded, Suter having probably mistaken examples of one of the *Verconella* n. spp. mentioned above for the South American shell.

The species of *Aethocola* are in no better state. Suter's *S. nodosa zitteli* is well worthy of specific rank, but the Target Gully shells so named are very different from both the type from White Cliffs and the described specimen from Nelson, which itself is not conspecific with the type. The Target Gully shell is a new species, and it was also on a variant of this that Suter's record of *S. conoidea* (Zitt.) was based, so that *S. zitteli* Sut. and *S. conoidea* (Zitt.) should disappear from these lists.

To summarize, the actual species of these shells that occur at Target Gully are

Verconella n. sp. (formerly termed *adusta* Phil.).
Verconella n. sp. (formerly termed *dilatata* Q. & G.).
Verconella excelsa (Sut.).
Aethocola costata (Hutt.).
Aethocola n. sp. (formerly termed *zitteli* Sut. and *conoidea* Zitt.).

Of the five species of *Turritella* listed, not one is correct; they should be replaced by *T. cavershamensis* Harris, *T. abscisa* Sut., and two or three new species. Similarly, nearly all the Turritellas given in the lists from Ardgowan, Pukeuri, and Awamoa are wrongly named and must be omitted. All the species of *Fulgoraria* are likewise incorrect, there being six new species of Volutes, together with *Miomelon parki* (Sut.), which is not synonymous with *M. corrugata* (Hutt.). The name *Alcithoe* (the genotype of which is *F. arabica* Mart.), which Suter uses as a subgenus of *Fulgoraria*, should replace this, and be used as the generic name for these shells, true *Fulgoraria* having a different apex.

Mr. Marwick in his paper on *Glycymeris* (9b) has shown that *G. subglobosa* Sut. does not occur at Target Gully, being restricted to the lower Waiarekan; that *G. globosa* (Hutt.) is preoccupied by Sowerby and is renamed *G. huttoni* Marwick; and that the Target Gully shell differs again and is named *G. robusta* Marwick. Again, in a revision of our species of *Struthiolaria* he has separated the Oamaru forms from *S. cincta* Hutt. and *S. tuberculata* Hutt., with which they have previously been confused, and named them *S. subspinosa* Marwick. This is the common *Struthiolaria* occurring at Oamaru localities, the only other species being *S.* cf. *obesa* Hutt. (Awamoa beach boulders), *S. calcar* Hutt. (Ardgowan neotype), *S. spinosa* Hect. (Ardgowan), and *S. tuberculata* Hutt., one perfect and typical specimen of which I have found at Target Gully.

Of the four species of *Ancilla*, only one, *A. hebera* (Hutt.), should be retained. Mr. Marwick has shown (9a) that *A. papillata* Tate has been wrongly recorded, and he has renamed the large Awamoan species to which that name had been applied by Suter *A.* (*Baryspira*) *robusta* Marwick.

Although not mentioned in the Target Gully lists, *Surcula oamarutica* Sut. is given by Suter as occurring here, and is noted in the list of shells from Ardgowan. This species was described from a stray specimen in Suter's collection and several specimens which had been collected at Target Gully by Professor J. Park, and has not been recorded from any but these two localities. It might thus be regarded as a typical fossil of this deposit were it not for the fact that it is probably identical with *Turricula* (= *Surcula*) *fusiformis* (Hutt.), a common fossil at Oamaru localities. If the two diagnoses are carefully compared, it will be seen that they run practically parallel except for the number of nodules (12 in *oamarutica*, shell of 11 whorls; 10 in *fusiformis*, shell of 8–10 whorls) and the greater height of the spire in *oamarutica*. Both these characters are, of course, specifically unreliable in such a genus as *Turricula*, and *T. fusiformis* (Hutt.) is especially variable in these respects. The only plentiful large *Turricula* at Target Gully is *fusiformis* (Hutt.): I have collected exhaustively at this locality and found no other, much less "a number of specimens." After examining over a hundred specimens from Target Gully, many from Ardgowan and from Pukeuri, and several from Awamoa, Devil's Bridge, Rifle Butts, and Mount Harris, and after comparison with the holotype of *T. fusiformis* (Hutt.) in the Otago Museum, I cannot find any constant differences between the species, and think it probable that *T. oamarutica* (Sut.) is merely a gerontic form of

T. fusiformis (Hutt.). Since, however, I have shown (2*b*) that this name is preoccupied, the alternative term *T. oamarutica* (Sut.) should be used to cover all these shells. I have a strong suspicion that *S. huttoni* Sut. will also prove inseparable from *T. oamarutica* (Sut.), but, not having seen the holotype, I cannot yet express a definite opinion. In the present list all these forms are included under *T. oamarutica* (Sut.).

Similar confusion prevails in regard to the shells named by Suter *Leucosyrinx alta* subsp. *transenna* (*N Z. Geol. Surv. Pal. Bull. No. 5*, p. 44) and *Bathytoma antecostata* (*loc. cit.*, p. 53). Marshall and Murdoch (8*d*, p. 126) have referred the subsp. *transenna* also to *Bathytoma*, and it may be left there for the present, though not really related to that genus. It seems to grade easily into *B. antecostata* Sut. at Target Gully, and it is doubtful whether the latter species should be retained. Suter's records of *B. albula* (Hutt.) from Oamaru localities are based on these forms; the Recent species does not occur in the Awamoan. Of the two remaining species of *Bathytoma* admitted by Suter, *B. perlata* Sut., though not typical, may stand for the present, but *B. sulcata* (Hutt.) is a *Pseudotoma*, and on account of the preoccupation of Hutton's name has been renamed *P. huttoni* Finlay (2*b*).*

Suter has described as distinct species *Tritonidea compacta* Sut. and *Tritonidea elatior* Sut., and these two are quite different from the only other New Zealand species, *T. acuticingulata* Sut. (also plentiful at Target Gully), but very similar to each other. Two years ago I found difficulty in allotting the dozen specimens I then had to these two species. Now, with over a hundred specimens, the difficulty has increased so much that the only conclusion possible is that the two forms must be united, *T. elatior* Sut. being only a slender juvenile form of *T. compacta* Sut. On comparison of the diagnoses the points of separation seem at first to be fairly numerous viz., solidity of shell, number of axials per whorl, height and angle of spire, protoconch, and tubercles on the inner lip. Taking these points in turn, one finds from a study of a large suite in conjunction with the types of the two species that—(1.) Shells otherwise the same are quite indifferently thin or solid. (2.) The spire varies from a little less than the height of aperture and canal to considerably more than this height, its angle consequently varying greatly. (3.) The axial ribs vary from 9 to 16 per whorl, but are generally 11 or 12; they may be very sharp and prominent on the body-whorl, or low and flat, and they usually become obsolete on approaching the aperture; sometimes they are restricted to the upper whorls, the body and penultimate whorls being smooth except for spiral sculpture. (4.) The spirals may be sharp and distant or flattish and close together, the interstices varying from two-thirds to four times their width. (5.) The tubercles on the inner lip vary in number between 8 and none at all: they are quite irregularly spaced, and may be strong or weak. (6.) The protoconch is also variable, mostly 1¾ whorls, sometimes set obliqely to the shell-axis, the nucleus prominent or inconspicuous. These facts show how extremely inconstant this species is. Another variant seems to be the form described by Marshall and Murdoch (8*c*, p. 83) as *Euthria subcallimorpha*. This species is widely different from *Euthria callimorpha* Sut., which belongs to a totally unrelated genus; but if the figure is compared with that of *Tritonidea elatior* Sut. it will at once be seen that the shells are congeneric,

* In this change I have been anticipated. I notice that in the *Revue Critique de Paléozoologie* (received since the reading of the paper), vol. 20, No. 1, January, 1916, p. 9, Cossmann has noted the preoccupation of this name, and has supplied a substitute; the correct name is therefore *Pseudotoma suteri* (Cossmann).

and, in my opinion, also conspecific. *E subcallimorpha* has only 8 ribs on the body-whorl; this seems to be due to the wide spacing and obsolescence near the aperture, for the figure shows more ribs on the spire-whorls; in any case, this feature is very variable. The only important difference seems to be the spiral sculpture, which in *E. subcallimorpha* is said to consist of "fine, close, incised lines, forming lightly raised threadlets on the upper spire-whorls." But it is also mentioned that the only example is rubbed; wearing of the spiral ridges in this shell produces a groove down the centre, so that a shell in which the ribs are originally close seems to have a sculpture of still closer linear grooves when worn. Although no specimen in my collection exactly matches *E. subcallimorpha* M. & M., every point mentioned can be matched on different shells. As in the case of *Bathytoma transenna* (Sut.), the conditions prevailing at Target Gully seem to have induced excessive variation, but for all these forms only one species can be admitted. So many different forms occur that it is impossible to find valid distinctions, no one difference being constant. *Tritonidea compacta* Sut. has priority of place, and, as it was mentioned earlier in this paper that the generic name *Pollia* must displace *Tritonidea*, the species *T. compacta* Sut., *T. elatior* Sut., and *Euthria subcallimorpha* M. & M. should be united under the name *Pollia compacta* (Sut.). Even this, however, is only provisional, for these shells are congeneric with the Pliocene *Euthria striata* (Hutt.) (which again differs from the Recent shell so called). Iredale (2*d*) has separated our Recent Euthrias from the true European forms under the genus-name *Euthrena*, and *E. striata* (Hutt.) does not seem congeneric with *E. vittata* Q. & G., the type of this genus; it may, however, be possible to place it in *Evarne*, the type of which is *E. linea* Mart., but I have not enough Recent material to judge at present. The correct placing of this group will demand much labour. While this subject is being dealt with, it may be iterated that the records of *Verconella caudata* (Q. & G.) from Target Gully are based on examples of *P. compacta* (Sut.) which have lost the outer lip and have no denticles on the columella.

The case of *Natica zelandica* Q. & G. needs consideration. Doubt has been thrown by other writers (7) on Suter's accuracy in identifying the small fossil Naticas, so plentiful in Awamoan horizons, with the Pliocene and Recent form; and here, again, study of a large number of specimens shows that Suter erred. Castlecliff forms, allowing for individual variation, are identical with the Recent shell, but I have so far failed to find *N. zelandica* Q. & G. in any Awamoan horizon, the nearest approach to it being specimens of a new species from White Rock River, which, though decidedly distinct, is in some ways intermediate between *N. zelandica* Q. & G. and the common *Natica* of Awamoan localities. This latter form, which has been generally taken for *N. zelandica* Q. & G., differs from it in many respects, notably its consistently smaller size and totally different spire. It is very plentiful at Target Gully and Pukeuri, and occurs at most Miocene localities. A third species, occurring at Pukeuri, Target Gully, and Ardgowan, though much less frequently than its companion, is more nearly allied to the White Rock species, and, like it, bears a superficial resemblance to *N. zelandica* Q. & G. *Natica maoria* Finlay (= *australis* Hutt. (5)) and *Polinices vitreus* (Hutt.) are also represented in Awamoan beds by distinct species. These new species, together with many others, will be described and figured later, but in the meantime *Natica zelandica* Q. & G., *N. maoria* Finlay, and *P. vitreus*

(Hutt.) must be omitted from the Target Gully, Pukeuri, Ardgowan, and Awamoa lists, and from all other Awamoan lists.

In the Veneridae more confusion seems to exist than anywhere else. By far the commonest Venerid at Target Gully is the shell Hutton described (5) as *Chione vellicata*, of which species the later *Cytherea chariessa* Sut., from Otiake, is undoubtedly a synonym. In the collection of the Otago School of Mines, specimens of this shell are indiscriminately labelled *Chione meridionalis* (Sow.), *Cytherea oblonga* (Hanley), and *C. subsulcata* (Sut.). Since the list-names are apparently based on such records as there, it is unquestionable that several of the names must be dropped, as the species to which they refer do not really occur at Target Gully. Instances of this are *Cytherea sulcata* (Hutt.) and *C. subsulcata* (Sut.). As a result of weathering, the sculpture of Target Gully shells is not normal—the ribs appear too far apart; it is only on Pukeuri and Otiake specimens that the true sculpture of fine, close, erect lamellae is seen. Cossmann has stated that the *C. oblonga* (Hanley) of Target Gully differs from Pliocene forms, and has proposed the name *C. suboblonga* (1). As there is no published figure or description of this shell, Cossmann's name is a *nomen nudum*; but there is at Target Gully a species heavier than *C. vellicata* Hutt., and with different hinge, and this is probably the species referred to by Cossmann.* *C. yatei* Gray (which, by the way, is the type of Iredale's genus *Callanaitis* (6c), and should bear this genus-name) does apparently occur at Target Gully, one shell having been found which is inseparable from Recent examples. *Callanaitis speighti* (Sut.) is listed from Awamoa; I have found one fragment of this species at Target Gully. Not so rare, but still rather uncommon, is the shell Suter identified as *Chione mesodesma* (Q. & G.), but which Cossmann considers distinct from this Recent species and names *C. marshalli* (1)—another *nomen nudum*. Study of a dozen or so specimens shows quite clearly that the shell is easily separable from *C. mesodesma* (Q. & G.) by its thinner, smaller, and more elongate shell, and its much finer sculpture, the ribs being narrower and almost twice as dense as in the Recent shell.

There is room for doubt as to the correctness of the identification in the following cases: *Crassatellites obesus* (A. Ad.), *Placunanomia zelandica* (Gray), *Steptochetus* n. sp., *Turbonilla prisca* Sut., *Sinum carinatum* (Hutt.), and *Heliacus imperfectus* Sut. Notes on these are given as follows:

Crassatellites obesus (A. Ad.) has been stated by Murdoch (in 7) to differ from the Recent form. Study of the very plentiful Target Gully material shows the shell to be very variable in shape and dimensions; also, Target Gully forms are generally almost smooth except for a small concentrically-sculptured area below the beaks, while forms from other localities are generally strongly ribbed all over. Much material from other localities must be studied before it can be decided whether these and other differences are specific, varietal, or merely local. It may be noted that young shells of the nearly allied Wharekuri species *C. subobesus* M. & M. are practically indistinguishable from *C. obesus* (A. Ad.): elongation occurs in a disproportionately rapid manner with age.

Placunanomia zelandica (Gray): There is considerable difficulty in correctly identifying fossil specimens of this genus and the related genus

* Mr. Marwick has completed a thorough revision of the New Zealand members of this family, and in his manuscript, which I have been privileged to see, has placed *C. suboblonga* in the section *Ventricola* of *Antigona*, and *C. vellicata* in the section *Ventricoloidea* of the same genus. He also rejects the records of *Dosinia greyi* Zitt. and *Macrocallista multistriata* (Sow.) from Awamoan localities.

Anomia. Oliver has recently (11) limited the New Zealand Recent species to two, *A. walteri* Hect. and *A. trigonopsis* Hutt., making *A. huttoni* Sut. a synonym of the latter, and removing *A. furcata* Sut. to the genus *Monia*, where *P. zelandica* (Gray) should accompany it. Suter (13*b*) recorded *M. furcata* (Sut.) from the Hutchinsonian of Mount Brown, and gave his opinion that the correct name for the common fossil *Anomia* was *A. trigonopsis* Hutt., of which *A. walteri* Hect. should be regarded as a synonym. Thus at present the Tertiary species are in a very unsatisfactory state; as regards *Monia*, only one Miocene species viz., *M. incisura* (Hutt.) should be recognized in the meantime.

Streptochetus n. sp. is probably a *Voluta* species or its cast. There is no such label in the Otago School of Mines collection, and Mr. Marwick informs me that there are no Target Gully specimens so named in the Geological Survey collection, while shells from Black Point and Kakahu so named by Suter are only Volutoid casts The name should be dismissed from the lists until better-authenicated specimens are found.

Turbonilla prisca Sut.: The identity of the specimens so named by Suter from Target Gully with the type from Blue Cliffs has yet to be confirmed. Cossmann has referred *T. oamarutica* Sut. to *Acirsella* (1) (misspelt *Acissella* in the reference), a genus of the Epitoniidae, and this is a much better location than *Turbonilla*. The apex is not heterostrophic, no fold whatever is visible on the columella, and the periphery is much more rounded than is usual in *Turbonilla*. There is another undescribed species of *Acirsella* at Target Gully and Pukeuri, and at least four true species of *Turbonilla*, one of which certainly seems to be a *Mormula;* but until specimens of *T. prisca* Sut. are examined it cannot be stated whether that species is a *Mormula* or an *Acirsella*. It may be noted, in passing, that the discontinuous varices which Suter emphasizes in the case of *T. prisca* Sut. are also present on most specimens of *A. oamarutica* (Sut.).

Sinum carinatum (Hutt.): No authentic records of this peculiar shell from any other than the type locality, White Rock River, are known. Suter's identifications from Target Gully and elsewhere are based on fragments of *Calyptraea*. For the present it had better be omitted from the Target Gully list.

Heliacus imperfectus Sut.: The holotype of this species should be in the Otago Museum, but cannot be found, and I know of no other specimen. The diagnosis that Suter was able to draw up is so poor as to render trustworthy identification almost impossible, and the worn state of the lost holotype makes its generic position so doubtful that the best thing to do under the circumstances is to drop this species altogether.

Phalium pyrum (Lamk.) is recorded from the Rifle Butts and Ardgowan, but no full-grown, or even half-grown, complete specimen of that species has been collected from Awamoan horizons so far as I am aware: the record from the two localities mentioned is based on juvenile shells alone. Some specimens in the Otago School of Mines collection from Awamoa are also labelled with this name. A comparison of these specimens and shells from Ardgowan, where the form is not uncommon (though no perfect shells have been found), with Recent specimens of the species shows that there are constant differences in the apices (*e.g.*, the spiral striation is much stronger and coarser, the keel of the spire-whorls is much more prominent, due to the greater strength of its nodules, &c.), and especially there are radical differences in the body-whorl, which in the fossil shells bears four nodulous keels, gradually decreasing in strength, but in the true *Cassidea pyra* (Lamk.) is practically smooth apart from

the one row of low nodules on the keel. The fossil shells, though at a casual glance deceptively like the Recent shell, are in reality only juvenile and imperfect forms of a shell long known from the Oamaru Tertiaries namely, *Galeodea senex* (Hutt.). The occurrence of these "*pyrum*" forms together with perfect adult shells at Pukeuri and Ardgowan enables a direct comparison to be made, and the identity of the two is certain, so that the record of *C. pyra* (Lamk.) from Awamoan horizons should be replaced by that of *Galeodea senex* (Hutt.). The shell of *Galeodea senex* (Hutt.) being fragile, and its distribution in Oamaru localities wide, it is not surprising that, though the occurrence of perfect specimens is rare, the finding of apical fragments is not uncommon, and, as these fragments, as noted, have given generic trouble in one case, it is quite possible that they may have done so in other cases. Thus specimens in collections have quite possibly been included under *Struthiolaria* (whose apex they much resemble, especially when worn), *Siphonalia*, and *Ficus*.

This completes the rather lengthy tale of necessary alterations in the list as it stands at present. At the same time, however, it must be borne in mind that no European palaeontologist has yet examined any considerable number of our Tertiary species; when this is done we may expect extensive alteration in the generic names at present adopted, and in many cases the location of shells of which there are no New Zealand Recent representatives must be regarded as tentative.

Some remarks on the general variation noticeable at Target Gully may not be out of place here. As mentioned by Park (12, p. 93), the deposit is of no great depth, though deep- and shallow-water shells are intermingled, and many rolled fragments are present, showing that the shell-bed was subject to strong disturbances while being laid down. This unsettled nature of the habitat induced great variation in certain species which under normal conditions were fairly constant. It must have been a period of stress and struggle and rapid change of environment. For this reason Target Gully is not always a satisfactory collecting-ground: though species and specimens are very numerous, they are often ill-preserved, and, worse still, atypical. If a species occurs there and also at another locality, it is generally safer to take the second form as the more typical one. The application of this really matters, however, in only a few special cases, practically all noted previously in this paper; the majority of the Target Gully shells form very satisfactory and fairly constant specimens. The Ardgowan shell-bed, which of all the Awamoan horizons is the nearest approach to the actual Target Gully bed, is very similar to it stratigraphically and palaeontologically; the sandy matrix is lighter in colour, though glauconite is more abundant, and the fossils are often much more poorly preserved and fragile than at Target Gully, with a characteristic whitish and often chalky appearance. There is a considerable difference in the common species, and the Ardgowan fauna is not so rich as the Target Gully fauna, though the species are much more constant, this bed being deposited probably during quieter conditions. Among the species which are fairly constant at Ardgowan but variable at Target Gully are *Xymene lepidus* (Sut.), *Pollia compacta* (Sut.), *Turricula oamarutica* (Sut.), *Venericardia lutea* (Hutt.). The Pukeuri beds consist of very fine sandy material, well consolidated, and, when damp, almost of the consistency of clay. Very poor results are obtained if fossils are sought in the dry bank, either by scanning or by digging; the specimens are quite hidden by the matrix unless well weathered out, and are also exceedingly fragile. Fortunately the clay crumbles readily on sieving in water, a

surprising amount of rich and clean material remaining. Target Gully and Ardgowan shell-sand is more satisfactorily sieved in the dry state. Awamoan clay is much more difficult to work with, and crumbles only very slightly in water. Otiake sandy matrix crumbles easily in the dry state, but not any more easily when damp.

The state of the beds at Pukeuri indicates peaceful deposition. Perfect shells are more often found, and there is little variation: it is consequently a good locality for typical specimens. Interesting minutiae also abound here. Variable Target Gully shells which are fairly constant at Pukeuri are *Acirsella oamarutica* (Sut.), *Bathytoma transenna* (Sut.), *Cerithiella fidicula* Sut., *Corbula pumila* Hutt., *Mesalia striolata* (Hutt.), and *Vexillum fenestratum* Sut. Other very variable Target Gully species are the forms of *Turritella*, *Ancilla*, and *Terebra orycta* Sut.

The lists of shells from Pukeuri, Ardgowan, and Awamoa may be brought up to date by making the same corrections as indicated here for the Target Gully list, and adding the following new records.

Pukeuri List.

Add the species *Bullinella soror* (Sut.) [*Cylichnella*], *Alectrion laticostata* Sut., and *Brocchinia pukeuriensis* (Sut.) [*Ptychatractus*], originally described from this locality, but somehow omitted from the list; also *Pagodula vegrandis*, *Antimitra vexilliformis*, and *Columbarium maorium*, described by Marshall and Murdoch from this locality (8*d*); and the following forms:—

Acirsella oamarutica (Sut.). [*Turbonilla*.]
Bela infelix Sut.
Bela tenuilirata Sut. [*Ptychatractus*.]
Bullinella cf. *striata* (Hutt.). [*Cylichnella*.]
**Cadulus delicatulus* Sut.
Calliostoma suteri Finlay.
Calliostoma suteri var. *fragile* Finlay.
**Calyptraea tenuis* (Gray).
Chlamys chathamensis (Hutt.). [*Pecten*.]
**Crepidula monoxyla* (Less.).
Cucullaea australis (Hutt.).
**Dentalium ecostatum* Kirk.
**Divaricella cumingi* (Ad. & Ang.).
Erato neozelanica Sut. (Also from Devil's Bridge.)
Eulima obliqua (Hutt.).
**Gari* cf. *lineolata* Gray. [*Psammobia*.]
Lucinida laminata (Hutt.). [*Loripes*.]
**Macoma edgari* Iredale. [*Tellina glabrella*.]
Mactra cf. *discors* Gray.
Mactra scalpellum Reeve.
Mesalia striolata Hutt.
Monia incisura (Hutt.). [*Placunanomia*.]
**Murex zelandicus* Q. & G.
Nuculana cf. *semiteres* (Hutt.). [*Leda*.]
Pecten huttoni Park.
Pholadomya neozelanica Hutt.
**Philine constricta* M. & S. (New as a fossil.)
Pseudotoma suteri Cossm. [*Bathytoma sulcata*.]
**Rhizorus reflexus* (Hutt.). [*Volvulella*.]
Ringicula uniplicata Hutt.

Saxicava arctica (L.).
Sinum miocaenicum Sut.
Struthiolaria subspinosa Marwick.
**Tellina eugonia* Sut.
**Tellina liliana* Iredale. [*T. deltoidalis.*]
Terebra costata Hutt.
Trichotropis sp. near *clathrata* Sow.
Trivia avellanoides McCoy.
**Turbonilla zelandica* Hutt.
Typhis maccoyi T.-Woods.
Ventricoloidea vellicata (Hutt.). [*Chione.*]
Xymene lepidus (Sut.). [*Trophon.*]

ARDGOWAN LIST.

Actaeon praecursorius Sut.
Aethocola spinifera Finlay and McDowall. [*Siphonalia.*]
**Anomia trigonopsis* Hutt.
Bathytoma transenna Sut. [*Leucosyrinx alta transenna.*]
Bela tenuilirata Sut. [*Ptychatractus.*]
Brocchina pukeuriensis (Sut.). [*Ptychatractus.*]
Bullinella enysi (Hutt.). [*Cylichnella.*]
Bullinella soror (Sut.). [*Cylichnella.*]
**Cadulus delicatulus* Sut.
Calliostoma cancellatum Finlay.†
Calliostoma marwicki Finlay.
Calliostoma suteri Finlay.
Calliostoma suteri var. *fragile* Finlay.
Cerithiella fidicula Sut.
Chlamys (Pallium) burnetti (Zitt.). [*Pecten.*]
Chlamys chathamensis (Hutt.). [*Pecten.*]
**Chlamys radiatus* (Hutt.). [*Pecten.*]
Corbula pumila Hutt.
Couthouyia concinna M. & M. (Known previously only from the holotype from Target Gully.)
**Dentalium ecostatum* Kirk.
**Diplodonta globularis* (Lamk.).
**Divaricella cumingi* (Ad. & Ang.).
Dosinia magna Hutt.
Elachorbis helicoides (Hutt.). [*Circulus.*]
Elachorbis politus (Sut.). [*Circulus.*]
**Emarginula striatula* Q. & G.
Erato neozelanica Sut.
Galeodea senex (Hutt.).
Leucosyrinx alta (Harris).
Limea transenna Tate.‡
Limopsis zitteli Iher.
**Lucinida concinna* (Hutt.). [*Loripes.*]

† This name being preoccupied by Schefman (*Res. Siboga Exped.*, Livr. 39, p. 69, 1908), I propose to substitute for it the name *Calliostoma temporemuti* nom. nov.

‡ This is a very interesting discovery, as there are surprisingly few Australian fossils that are found in our Tertiaries, and this record adds a well-known Balcombian shell to their number. Three complete valves have been found here, but the shell has not been discovered elsewhere. Genus and species new to fauna.

**Macoma edgari* Iredale. [*Tellina glabrella.*]
Marginella fraudulenta Sut.
Mesalia striolata (Hutt.).
**Murex zelandicus* Q. & G.
**Nucula hartvigiana* Pfr.
**Nucula simplex* A. Ad. [*N. strangei* A. Ad., which does occur here, contrary to the statement in *Bull. 20.*—See 12.]
Nuculana cf. *semiteres* (Hutt.). [*Leda.*]
**Pleurodon maorianus* Hedley.
Pollia compacta (Sut.). [*Tritonidea.*]
**Protocardia pulchella* (Gray).
Pseudotoma excavata (Sut.). [*Bathytoma.*]
**Pteronotus angasi* (Crosse). [*Murex.*]
Ringicula uniplicata Hutt.
Struthiolaria calcar Hutt.
Struthiolaria spinosa Hector.
Struthiolaria subspinosa Marwick.
Terebra orycta Sut.
Trivia avellanoides (McCoy).
Typhis maccoyi T.-Woods.
Ventricoloidea vellicata (Hutt.). [*Chione.*]
**Zenatia acinaces* Q. & G.

Awamoa List.

There are several different kinds of matrix from which shells have been collected at this well-known locality, and lists from these will, if found necessary later, be given separately. In the meantime the new records made here are marked according to the matrix in which they were found (1) Shelly boulders cast up on the beach; (2) blue clays forming the banks of the creek; (3) very hard and rather poorly fossiliferous mudstones apparently resting on the blue clays, and cropping out all along the beach at high-tide level. Fossils often as casts, but no records are here made on such.

The list specimens come chiefly from (1), as also did the bulk of the Geological Survey Awamoa specimens, which were not examined by Suter. Good collections have not previously been made from the far more important locality (2).

Actaeon praecursorius Sut. (1).
Aethocola spinifera Finlay and McDowall (1).
**Amphidesma subtriangulata* Wood (3). [*Mesodesma.*] (New for the Miocene; the specimen is a young shell and may be referable to the subsp. *pliocenica* Oliver.)
Anomia trigonopsis Hutt. (1).
Bivetia brevirostris (Hutt.) (1). [*Latirus.*]
Brocchina pukeuriensis (Sut.) (2). [*Ptychatractus.*]
Bullinella soror (Sut.) (1 & 2). [*Cylichnella.*]
Corbula humerosa Hutt. (2).
**Crepidula monoxyla* (Less.) (1).
Crossea cf. *sublabiata* Tate (2). (Probably same as the species recorded by Marshall as *C. labiata* T.-Woods from Pakaurangi Point.)
Cucullaea alta Sow. (2).
Cucullaea alta var. B Hutt. (1 & 3).

Cucullaea australis (Hutt.) (1).
**Diplodonta globularis* (Lamk.) (1).
**Divaricella cumingi* (Ad. & Ang.) (1 & 2).
**Emarginula striatula* Q. & G. (1).
Galeodea senex (Hutt.) (2 & 3).
Glycymeris huttoni Marwick (1). [*G. globosa* (Hutt.).]
Lima bullata Born (2).
Lucinida laminata (Hutt.) (1 & 2). [*Loripes.*]
**Macoma edgari* Iredale (1 & 3). [*Tellina glabrella.*]
**Mactra* cf. *discors* Gray (3).
**Mactra scalpellum* Reeve (1).
**Malletia australis* (Q. & G.) (1, 2, & 3).
Monia incisura (Hutt.) (1 & 2). [*Placunanomia.*]
Pecten huttoni Park (3).
**Protocardia pulchella* (Gray) (1).
Pyrgulina pseudorugata (M. & M.) (2).
**Rhizorus reflexus* (Hutt.) (1). [*Volvulella.*]
**Serpulorbis sipho* (Lamk.) (1).
Sinum miocaenicum Sut. (2).
**Spisula* cf. *aequilateralis* (Desh.) (3). (New for the Miocene.)
Struthiolaria subspinosa Marwick (1 & 2).
Struthiolaria cf. *obesa* Hutt. (1).
**Tellina gaymardi* Iredale (3). [*T. alba* Q. & G.] (Record confirmed.)
**Tellina liliana* Iredale (1). [*T. deltoidalis.*]
Terebra orycta Sut. (3).
Teredo heaphyi Zitt. (1).
Ventricoloidea vellicata (Hutt.) (1 & 3). [*Chione.*]
Vexillum linctum (Hutt.) (2).
Vexillum rutidolomum Sut. (3).
Xymene lepidus (Sut.) (2). [*Trophon.*]
**Zenatia acinaces* (Q. & G.) (1).

Add also the species *Eulimella awamoaensis* M. & M. (2) and *Turbonilla awamoaensis* M. & M. (2), recorded by Marshall and Murdoch (8c), but not *Daphnella varicostata* M. & M., which is a synonym of *Bela canaliculata* Sut. (see *ante*). Besides the above, the following forms have been recorded as occurring at Awamoa. They are not given in the list, but are mentioned in various places in *Pal. Bull. 2, 3,* and *5*—in several cases as holotypes.

Aethocola costata (Hutt.) (2 ?). [*Siphonalia.*]
Bathytoma transenna (Sut.) (2). [*Leucosyrinx.*]
Corbula kaiparaensis Sut. (2).
**Crassatellites obesus* (A. Ad.) (1, 2, & 3).
Drillia awamoaensis (Hutt.) (2).
Lima colorata Hutt. (1, 2, & 3).
Limopsis zealandica Hutt. (2). [*L aurita* Brocchi : not of Brocchi.]
Rissoina vana Hutt. (2). (In another paper in this volume (p. 493) it is shown that this name should be omitted from these lists.)
Trigonia semiundulata Jenkins. [*T. subundulata* Jenkins.] (Mr. Marwick has shown that this record should be deleted, as it is based on an Australian specimen.)
Turricula huttoni (Sut.) (1 & 2). [*Surcula.*]

The above lists considerably reduce the number of species peculiar to any one of the localities, and it is very probable that more exhaustive collecting would still further reduce them.

A *résumé* of new points in connection with nomenclature and range of species indicated in this paper would run as follows :—

(1.) New generic placings :—

Latirus brevirostris (Hutt.) ..	*Buccinulum.* (?)†
Circulus helicoides (Hutt.)	*Elachorbis.*
Circulus politus Sut.	*Elachorbis.*
Circulus cingulatus Bart.	*Elachorbis.*
Odostomia pseudorugata M. & M.	*Pyrgulina.*
Cymatium suteri M. & M. ..	*Xymene.*
Austrotriton neozelanica M. & M.	*Charonia.*
Ptychatractus tenuiliratus Sut. ..	*Bela* (provisional).†
Ptychatractus pukeuriensis Sut.	*Brocchinia* (provisional).†
Admete anomala M. & M. ..	*Brocchinia* (provisional).†
Borsonia cincta (Hutt.) ..	*Brocchinia* (provisional).†
Admete lacunosa Hutt. ..	*Bonellitia.*
Leucosyrinx transenna Sut. ..	*Bathytoma* (provisional).

(2.) New synonyms advocated (correct name second) :—

Protocardia sera Hutt. ..	*P. patula* (Hutt.).
Corbula canaliculata Hutt. ..	*C. humerosa* Hutt.
Daphnella varicostata M. & M. ..	*Bela canaliculata* Sut.
Surcula fusiformis (Hutt.) ..	*Turricula oamarutica* (Sut.).
Surcula huttoni Sut.	*Turricula oamarutica* (Sut.) (?).
Tritonidea elatior Sut. ..	*Pollia compacta* (Sut.).
Euthria subcallimorpha M. & M.	*Pollia compacta* (Sut.).
Cytherea chariessa Sut. ..	*Antigona vellicata* (Hutt.).

(3.) Species wrongly recorded from the Awamoa stage :—

**Thoristella chathamensis* (Hutt.).
**Trochus tiaratus* Q. & G.
**Cantharidus tenebrosus* A. Ad.
**Venericardia difficilis* (Desh.).
**Crepidula costata* (Sow.).
**Xymene quirindus* Iredale.
Mitra armorica Sut.
**Nozeba emarginata* (Hutt.).
**Fusinus spiralis* (A. Ad.).
Cymatium minimum (Hutt.).
Turris regius Sut.
Borsonia (all species).
**Verconella caudata* (Q. & G.).
**Verconella dilatata* (Q. & G.).
**Turritella*, **Ancilla*, and **Alcithoe* (all Recent species).
Glycymeris subglobosa Sut.
**Bathytoma albula* (Hutt.).
**Natica zelandica* Q. & G.
**Natica maoria* Finlay.
**Polinices intreus* (Hutt.).
**Antigona oblonga* (Hanley).
Chione subsulcata Sut.
**Chione mesodesma* (Q. & G.).
**Cassidea pyra* (Lamk.).

† See addendum.

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ADDENDUM.

Most of this paper was written more than two years ago. Since then much new material, both Neozelanic and foreign, has come into my hands; also, I have much information that was not then available; and I now find that it will be imperative to create new groups for some of the species discussed. It is wiser to give a difficult species a niche of its own than attempt time and again to force it into genera which will not satisfactorily contain it. As it will be some years before all the various genera discussed can be treated separately, and confusion over these species will but increase during that time, I have decided to deal with some of the more urgent cases now, and herewith propose new genera for their reception. Incorporation of these in the paper would have necessitated so much alteration of the type that my earlier remarks have been allowed to stand, and the new names all brought together in a postscript.

INGLISELLA n. gen. Type, *Ptychatractus pukeuriensis* Sut.

Classed provisionally as a *Brocchinia* in the paper, this shell and its allies differ from that genus in the thin shell, different form of growth, discrepant sculpture, much straighter columella, and rather pronounced posterior notch in the outer lip just at the keel.

The genus-name for these attractive little shells is with much pleasure given in honour of Dr. J. K. H. Inglis, of Otago University, in appreciation of his unfailing kindness and consideration.

MAORIVETIA n. gen. Type, *Turbinella brevirostris* Hutt.

The various previous locations of this shell in *Turbinella*, *Peristernia*, *Taron*, *Latirus*, *Aphera*, *Leucozonia*, and, finally, *Bivetia*, sufficiently attest

the need for a new division. The shell is very peculiar, having the very large protoconch of *Uxia* (but far more asymmetrical, and with an immersed nucleus), the shell formation of *Aphera,* the strong basal fasciole and notch of *Cancellaria*, a slight umbilicus, and a straight columella. The general appearance is that of *Bivetia,* but the anterior notch is more lateral, the columella plaits different, and the pillar much less bent backwards and twisted; the apex disagrees radically. Cossmann, in mentioning this shell, has already indicated the probable need for a new group. *Merica wannonensis* (Tate) has a somewhat similar aperture, but a different form of growth and embryo.

OAMARUIA n. gen. Type, *Admete suteri* M. & M.

This shell and its Australian allies do not correlate well with any Cancellarid group: the reticulate sculpture of strong, sharp, spiral and axial ridges; the very strong peripheral keel, and wide, smooth shoulder; the inflated body-whorl, and rather short spire; the mere truncation of the slightly developed canal; the absence of fasciole and umbilicus; the straight pillar, flexed a little to the left below, and bearing two close, transverse plaits as in *Inglisella,* with a third spirally twisted, almost vertical ridge forming the base of the columella; and the small, one-whorled, askew protoconch, form a characteristic and easily recognized combination.

NASSICOLA n. section. Type, *Neptunea costata* Hutt.

In shape and appearance of canal somewhat intermediate between *Aethocola* and *Cominella*, but the apex shows that relationship is really with the former. The strong, keeled fasciole; the short and rather indistinct canal, bent strongly to the left instead of spirally downwards; and the general habit of the shell, all demand sectional recognition under *Aethocola.* Further species of both *Aethocola* s. str. and of *Nassicola* are awaiting description.

RUGOBELA n. gen. Type, *Ptychatractus tenuiliratus* Sut.

This shell and its Neozelanic and Australian allies have been fully discussed in the paper, and the necessity there shown for a new genus.

PARASYRINX n. gen. Type, *Pleurotoma alta* Harris.

Related to, and classed by Suter under, *Leucosyrinx*, which has a different type of sculpture; shorter, more flaring, and more bent canal; and much shallower, more open sinus. The sinus of *Parasyrinx* is in shape and depth quite reminiscent of *Bathytoma,* but is on the lower third of the shoulder instead of on the keel. Characteristic of the new genus, too, is the one strong peripheral keel, the typical species being otherwise quite bare of ornament, though other forms have weak basal spirals. Here may be placed *Leucosyrinx subalta* M. & M. and *Surcula protransenna* M. & M. There are several genera to which these shells bear resemblance: *Leucosyrinx, Irenosyrinx,* and *Steiraxis* all contain forms more or less superficially similar to species of *Parasyrinx,* but, on close inspection, uniformly of a different facies; their sinus is open and not deep, and the pillar much shorter and obliquely truncated. *Parasyrinx* has a but faintly twisted, long, slowly narrowing pillar. *Ancistrosyrinx* and *Rouaultia* are likewise carinated,

but the former has a recurved, spiny keel, and a sutural sulcus bounded be an elevated ridge, while the latter has a stout, twisted pillar, and the sinus on the keel. Perhaps the nearest relative is *Cochlespira* Conrad, an Oligocene genus; but this also has a spiny keel, and the fasciole is separated from the suture by a beaded ridge.

AUSTROTOMA n. subgen. Type, *Bathytoma excavata* Sut.

For *Bela woodsi* Tate, an Australian Tertiary species, Cossmann has proposed the genus *Belophos*, which he places in the Buccinidae. This shell, however, belongs to the Turridae, being quite similar in facies to *Pseudotoma*, though it may at once be separated from the typical Italian forms by the deep basal notch, with its accompanying prominently carinated fasciole. *P. laevis* Bell. and *P. intorta* Br. have only a weak notch and a feeble fasciole, without a carina. The New Zealand species *B. excavata* Sut. and its allies (*B. eximia* Sut., *B. suteri* Cossm., *B. robusta* Hutt.,* *Clavatula neozelanica* Sut., &c.) seem to represent a later stage in development than *B. woodsi*, in that the axials tend to multiply, weaken, and ultimately vanish, and the spirals to form strong raised cords, often of greater general prominence than the axials. *B. woodsi* has (like *P. laevis* and *P. intorta*) weak and thin spirals, but strong, persistent, and far more prominent axials, and the body-whorl is anteriorly far more contracted. Evolution is also evident in the embryo, which in *P. intorta* has a planorbid tip and bears only spiral threads; in *B. excavata* Sut. the little pullus is erect and the whorls more closely knit, and for some distance before the terminal varix axial acceleration is shown, producing reticulation. Some of our species have already been referred by Suter to *Pseudotoma* Bell.; in rejecting this name from the Neozelanic fauna I would point out that *Pseudotomus* Cope, 1872 (Mammalia), has a year's priority and invalidates Bellardi's name. As a substitute, *Pseudotomina* nom. nov. (type. *P. laevis* Bell.) may be suggested as causing the least confusion. From study of the apex it would seem that *Pseudotomina* descended from a form whose forte was spiral ornament, perhaps *Cryptoconus* or *Conorbis*; strong axial sculpture (and, in *Belophos*, a basal notch) then developed; this became impressed on the protoconch in later forms, and finally began to grow obsolete again in *Austrotoma*, some of the New Zealand Pliocene forms of which have lost all but the embryonic remnants of axial ribs.

PHENATOMA n. gen. Type, *Pleurotoma novae-zelandiae* Reeve.

A shell with superficial resemblance to *Epideira* Hedley, to which genus its author has suggested it may be referred. There is really, however, no close relation between this shell and *E. striata* (Gray): the differences will at once be apparent to New Zealand workers when it is stated that *Bathytoma nodilirata* (M. & S.) is a true *Epideira*. The latter genus is doubtfully distinct from *Epalxis* Cossmann, proposed for a few Parisian Eocene species which differed from *Bathytoma* s. str. in practically the same details as Hedley gives for *Epideira;* the types of the two genera are extremely similar shells. However, Hedley's name may perhaps be retained in a sectional sense, since the austral species seem to have uniformly

* Hutton's name dates from 1877; the same combination had been previously employed by Packard (*Mem. Bost. Soc. Nat. Hist.*, p. 232. 1869). The New Zealand shell may be renamed *Belophos (Austrotoma) minor* nom. nov.

shorter canals than the more ancient *E crenulata* (Lamk.) and its allies. *P. novae-zelandiae* Reeve has a narrower and deeper sinus than both these groups; it is not on the peripheral nodular row (which is never strong as in *Epideira*, and often quite obsolete), but just above it, in a rather smooth space, traversed always by at least one distinct spiral thread at the middle of the sinus. The spire is higher, the shell more slender, and the bead-rows much less conspicuous The apex is absolutely different, being conic, polygyrate, and quite symmetrical, much taller than wide; the tip, though minute, not pointed but flatly depressed and slightly immersed, not at all bulbous. And, lastly, a radical difference is the possession by *Phenatoma* of a strong basal notch in the canal, giving rise to a prominent fasciole and carina, just as in *Belophos* and *Austrotoma*. On account, however, of the wide differences in embryo and anal notch, *Phenatoma* does not seem otherwise closely allied to the Pseudotominae. To *Phenatoma* may also be referred *Drillia cheesemani* Hutt (*Bathytoma*), and *Pleurotoma plicatella* Hutt. (*Drillia*). Closely allied also is the group of shells centring round *Pleurotoma albula* Hutt.; these forms are very common in the New Zealand Tertiaries, and form an easily recognized division of *Phenatoma*, as follows:

Cryptomella n. subgen. Type, *Leucosyrinx transenna* Sut.

In common with the restricted forms these shells possess a basal notch and fasciole, but both these and the carina are weaker; the sinus and its traversing thread are the same, as also are the details of the aperture and the relative proportions. The species are of smaller size, and a highly typical feature is the development of a strong peripheral keel, instead of bead-rows and axial ribs, somewhat as in *Parasyrinx*; one of these usually sharply carinates the spire-whorls at the lower third or fourth, but thence often becomes obsolete, leaving the body-whorl rounded. The most important difference, however, is in the apex, which, though of the same essential construction, has only two much larger and stouter whorls, thus losing its polygyrate, pointed appearance, and becoming bluntly conical and a trifle asymmetrical. With the genotype I would associate the following species: *Drillia multiplex* Webster, *Defrancia excavata* Hutt. (*Genotia*), *Pleurotoma albula* Hutt. (*Bathytoma*), *P. subalbula* Murd., and *Bathytoma antecostata* Sut. Hedley has referred *P. albula* to his *Filodrillia*. This, as at present constituted, is a heterogeneous group, containing at least three diverse elements. None of these will satisfactorily receive *P. albula*; as in the case of *Phenatoma*, the presence of a basal notch, fasciole, and carina in the New Zealand shell outweighs superficial similarity of habit, and renders close relation improbable. *F. steira* Hedley is, from the figure, very much like a *Cryptomella*, but from neither the diagnosis nor the illustration can the presence of a basal notch be deduced. Nevertheless I think it will prove to be present in that, and possibly other, Australian species. It is worthy of note that *Inquisitor metcalfei* Angas seems to be an *Austrotoma*, closely related to the New Zealand *Drillia optabilis* M. & S.

Additions to the Recent Molluscan Fauna of New Zealand.

By H. J. FINLAY, M.Sc., Edmond Fellow of Otago University.

[*Read before the Otago Institute, 12th December, 1922; received by Editor, 31st December, 1923; issued separately, 30th July, 1924.*]

Plate 52.

SEVERAL new species discovered in seaweed-washings from Taieri Beach (a few miles south of the Taieri River), and in oyster-scrapings from the Bluff, and one or two larger species from other localities, are described in the following paper. Of especial interest are the records of *Cassidea stadialis* Hedley and *Charonia lampas* var. *euclia* Hedley: their size and appearance render them striking additions to the fauna of a land whose mollusca are in general not remarkable for their beauty. The writer would also like to make the following new records for the localities mentioned:

(1.) Bluff (Oyster-scrapings).

Orbitestella hinemoa Mestayer. Recorded only from Snares Island (50 fathoms).

(2.) Taieri Beach.

Musculus barbatus (Reeve). In seaweed and sponges.

Rochefortia reniformis Sut. Recorded only from fairly deep water, but not uncommon on the littoral attached to the under-side of muddy rocks.

Callanaitis yatei (Gray).

Callochiton platessa Gould. Two specimens of this rare shell, on stones in a channel bare at extreme low tide.

Lorica haurakiensis Mestayer. One valve, on the beach.

Schismope brevis var. *laevigata* Iredale. Seaweed-washings.

Incisura lytteltonensis (Smith). Seaweed-washings; not uncommon.

Thoristella dunedinensis (Sut.).

Margarella decepta Iredale. Very plentiful under kelp-roots. This record extends the southern range of the species, but is it probably still common much farther south before its place is taken by *M. antipoda* H. & J.

Notosetia micans (Webster). Seaweed-washings.

Notosetia subflavescens Iredale. Seaweed-washings.

Subonoba foveauxiana (Suter). Seaweed-washings.

Skenella pfefferi Suter. Seaweed-washings; very common. This record extends the southern range of the species considerably.

Eatoniella impolita (Hutt.). In muddy crevices.

Pirene retiolum Hedley. Recorded in an earlier paper in this volume (p. 462) from a broken shell cast up on the rocks.

3. Dunedin Harbour.

Musculus barbatus (Reeve).

Rochefortia reniformis Sut. Littoral (*vide ante*).

Erycina parva (Desh.). With *Lasaea*, attached to the under-side of stones, but rare. Recorded only from fairly deep water.

Mactra ovata var. *rudis* Hutt.

Callochiton empleurus (Hutt.). One example, on the littoral. Previously known only by one or two specimens from Foveaux Strait; fairly deep water.

Rhyssoplax canaliculata (Q. & G.). One specimen, on the littoral, together with *R. aerea* (Reeve). Recorded only from deep water.
Patelloida stella (Lesson). One living specimen.
Tugalia bascauda Hedley. One living specimen.
Elachorbis subtatei (Sut.). In 20 fathoms, outside Otago Heads.
Astraea sulcata subs. *davisii* Stowe. Two juveniles, crawling among seaweed on the shore.
Lepsiella scobina (Q. & G.). The var. *albomarginata* Desh. is very common in the South Island, and occurs also in the North, but the species itself is recorded only from the North. It is therefore interesting to note that typical specimens, and all grades between it and the subspecies, were found by Mr. R. S. Allan while collecting with the writer, but were apparently restricted to a small isolated patch of rocks about two miles from Port Chalmers. Here, however, the probable recurrence of conditions similar to those prevailing in the North Island has induced local reversion to the strongly sculptured form.
Atrina zelandica (Gray). The length recorded by Suter for this species is 226 mm.; a specimen from Otago Heads (20 fathoms) measured 280 mm.
Calliostoma selectum Chemnitz. Suter gives the range of this species as from Auckland to Cook Strait. Some half-dozen very large and fine examples were obtained in 20 fathoms off Otago Heads, the largest reaching 65 × 55 mm.
Calliostoma tigris Martyn. The same remarks apply to this species also, except that only two shells were obtained. Suter gives the dimensions as 58 × 59 mm., but the larger of the above two specimens measures 72 × 75 mm.
Charonia lampas var. *euclia* Hedley. Recorded elsewhere in this volume (p. 462) from a specimen obtained outside Otago Heads in 22 fathoms.
Cassidea sulcalis Hedley. This is dealt with later in the paper.

Elachorbis diaphana n. sp. (Fig. 1.)

Shell minute, depressed-turbinate, finely spirally lirate, perforate. Test translucent, protoconch white, opaque. Whole surface covered with very fine and inconspicuous spirals; they are low and flattish with linear interstices and diminish a little as they near umbilicus. Spire about one-fifth height of aperture. Whorls 2½, slightly convex, body-whorl faintly and bluntly subangled; protoconch of 1 smooth whorl. Suture distinct, situated in shallow furrow. Aperture subcircular, slightly angled above. Peristome not continuous, outer lip advancing past inner; its ends are, however, connected by thin parietal callus. Umbilicus narrow, deep, perspective, one-seventh to one-eighth of major diameter.

Diameter, 0·75 mm.; height, about 0·4 mm.

Type in author's collection. One specimen, probably not adult; in oyster-scrapings from Bluff.

In its regular fine spiral striation, absence of distinct infrasutural sulcus, and incomplete peristome, this species resembles an undescribed new Tertiary species from Waikaia, but is amply distinguished by its much smaller size, convex base, and narrower umbilicus.

Zalipais parva n. sp. (Fig. 2.)

Shell very minute, discoidal, thin, smooth, perforate. Test subhyaline and, apart from growth-lines, quite smooth. Colour vitreous-white. Spire flat. Protoconch of 1 smooth rather bulbous whorl, relatively rather large,

but hardly elevated. Whorls 2¾; strongly convex, periphery and base rounded. Suture prominent, at the bottom of a rather deep furrow which causes whorls to appear bluntly angled on upper surface. Aperture as in *Z. lissa* (Sut.) but even less angled above, as in this species peristome

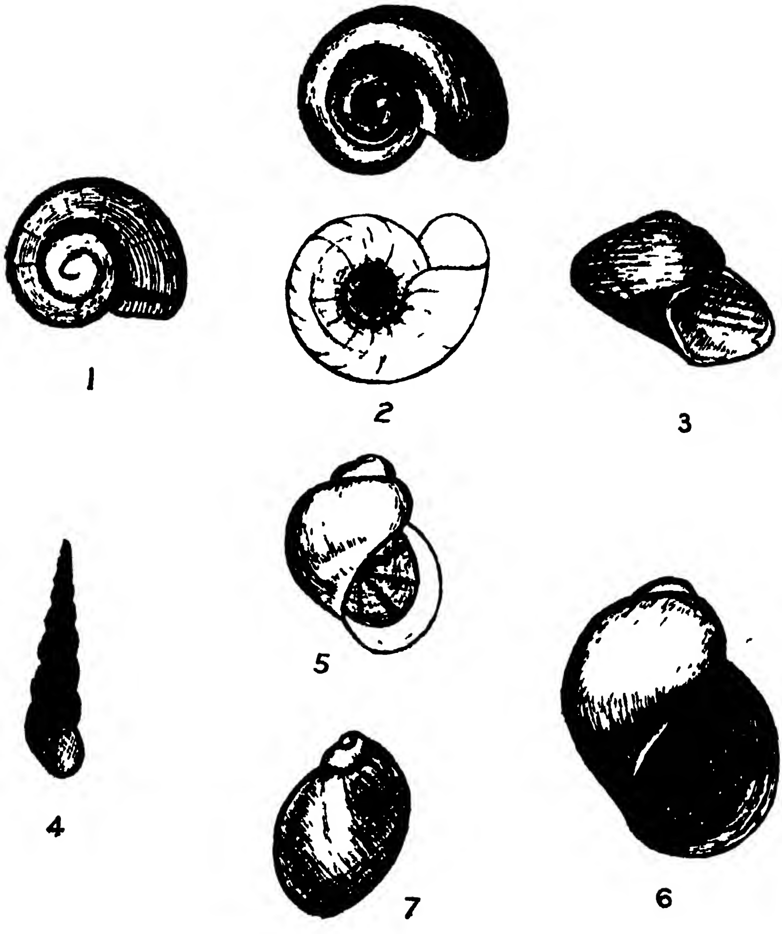


FIG. 1.—*Elachorbis diaphana* n. sp.: type. × 30.
FIG. 2.—*Zalipais parva* n. sp.: type. × 45.
FIG. 3.—*Talopena sublaevis* n. sp.: type. × 8.
FIG. 4.—*Turbonilla (Pyroglampros) blanda* n. sp.: type. × 10.
FIG. 5.—*Laevilitorina micra* n. sp.: type. × 33.
FIG. 6.—*Laevilitorina cystophora* n. sp.: type. × 34.
FIG. 7.—*Laevilitorina cystophora* n. sp: paratype. × 22.

is continuous and sharp and outer lip is advancing, thus producing sutural notch. Columella arcuate, hardly thickened. Umbilicus wide, more than one-third major diameter.

Diameter, 0·6 mm.; height, about 0·3 mm.

Type in author's collection. Two specimens; from seaweed-washings, Taieri Beach, together with *Z. lissa* (Sut.), which, however, is very much more abundant.

The new species differs at sight from *Z. lissa* (Sut.) in its smaller size (*Z. lissa* (Sut.) of a little over 2 whorls is 0·9 mm. in diameter), deeply furrowed suture, absence of sculpture, and much wider umbilicus, which in *Z. lissa* (Sut.) is not more than one-fifth major diameter.

Talopena sublaevis n. sp. (Fig. 3.)

Shell small, depressed-turbinate, perforate, thin, slightly sculptured. Spire low, about one-half height of aperture, outlines slightly convex. Protoconch lost, whorls about 4, subangled at periphery, earlier ones smooth, penultimate with traces of about 6 low flattish spiral ribs with linear interstices; the same sculpture continued over body-whorl, about 7 spirals above periphery and the same number below, less distinct on flatly convex base and with wider interstices; innermost one margins umbilicus and is obsoletely crenulated but otherwise not more prominent than the rest. No trace of axial sculpture. Colour rose and brown with lighter patches, base whitish. Suture impressed. Aperture subrhomboidal, angled above and below, very little nacreous within. Columella slightly reflexed and oblique, produced at base on meeting carina of umbilicus, which is narrow, deep, and funicular, about one-ninth major diameter, without entering ribs.

Diameter, 3·6 mm.; height, 2·3 mm.

Type in author's collection. One specimen, slightly worn and with the outer lip a little broken above; in oyster-scrapings from Bluff.

Easily distinguished from our other Recent species by its comparative smoothness and very narrow, unribbed umbilicus. Iredale has indicated (*Proc. Mal. Soc.*, vol. 13, p. 30; *Trans. N.Z. Inst.*, vol. 47, p. 439, 1915) that all the New Zealand species of *Solariella* are congeneric, so that the divisions employed by Suter (*Minolia, Monilea,* &c.) should not be used; but that, as the name *Solariella* was "given to a Crag fossil, it should not be used for Recent shells showing unlike shell characters." Accordingly he proposed *Talopena* (G.-T. *Monilea incerta* Iredale, from the Kermadec Islands), remarking that the Kermadec shell was typical of a well-marked austral group, from which one may conclude that he intended this name to be applied to *M. egena* Hutt., &c. This is too vague for present acceptance, since the Recent New Zealand species of *Solariella* are apparently generically inseparable from the abundant Pliocene, Miocene, Eocene, and even Palaeocene species that occur here. Thus either all our species should be referred to *Talopena* or else that name should be rejected altogether. It is a pity that Iredale did not explain more fully what he meant by "unlike shell characters," but as the similarity of our forms to *M. incerta* Iredale is certain, while their relation to the exotic species is somewhat doubtful, there is is apparently no course open but the acceptance of *Talopena*.

Xymene robustus n. sp. (Plate 52, figs. 4*a*, 4*b*.)

Shell small, fusiform, very solid, whitish, with axial and spiral ribs. There are strong, broadly rounded, slightly lamellose axials, 14–15 on penultimate whorl, with variable but usually subequal or slightly wider interstices, but at some distance from aperture axials lose their regularity and develop into prominent varices with sharp edge anteriorly; they are about twice as far apart as axial ribs; on body-whorl there are 7 axials and then 4 varices; they continue over base. Axial sculpture overlaid with spiral

Fig. 1.—*Leuconella marshalli* Murdoch. × 2.
Fig. 2.—*Leuconella compta* n. sp. × 2.
Figs. 3a, 3b, 3c.—*Cassidea costaliatis* Hedley. × 1.
Figs. 4a, 4b.—*Xymene robustus* n. sp. (*a*) Holotype, (*b*) paratype, nat. size.

cords: the spire-whorls with 2 equally strong, close spiral cords on the lower half, these, with another that emerges from suture, form 3 strong peripheral cords on body-whorl; between the lower two there is nearly always an interstitial riblet; 5 strong, gradually diminishing cords below these on base-whorl, with an additional 4 on base of body-whorl, interstices about equal to ribs, except on base where they are wider, rendered lamellose by growth-lines; shoulder generally smooth, but may bear 2 or 3 weak riblets. Colour whitish, aperture glossy white inside. Spire elevated, turreted, usually higher than aperture with canal. Protoconch small, of 2 glossy convex whorls, the first volution considerably tilted; 5 whorls remain, first 2 or 3 whorls subangled just above suture where axials suddenly become a little thicker, then sloping in to suture below, later whorls subquadrate, with an almost level shoulder, base rapidly contracted above canal. Suture indistinct. Aperture vertical, ovate, rounded above, produced below into a moderately long very narrow canal, slightly recurved and bent to left. Outer lip with a sharp edge but very rapidly thickening inside till the aperture is considerably reduced in area; 5 thick denticles rather far inside aperture, the lower 2 sometimes most prominent. Inner lip smooth, sharply marked off from body-whorl by groove extending from insertion of outer lip to end of canal. Columella vertical; bent, and drawn out to a fine edge along canal. Fasciole moderately strong, separated from inner lip by distinct umbilical chink.

Height (type, broken), 12 mm.; diameter, 5·5 mm.; height of aperture, 7 mm.

Height (paratype, adult), 17 mm., diameter, 8 mm.; height of aperture, 8 mm.

Type in the author's collection, dredged in 3 fathoms, Dunedin Harbour. One slightly beach-worn specimen found by Mr. R. S. Allan at the Otago Heads is referable to this species, and is the paratype here figured. Also a few specimens dredged in 60 fathoms off Otago Heads.

Note on **Onithochiton subantarcticus** Suter.

Suter, in the *Manual*, refers to this form as a chocolate-coloured variety of *O. neglectus* (Rochebrune) (*O. undulatus* Q. & G.), and records it from Auckland and Campbell Islands, Cook Strait, and New Brighton. Iredale (*Trans. N.Z. Inst.*, vol. 47, p. 423, 1915) remarks that "Suter's record of his var. *subantarcticus* from Cook Strait and New Brighton does not refer to this species, which is confined to the subantarctic islands, but belongs to a species quite distinct, but as yet unnamed." During the early part of the year the writer gathered two specimens of an *Onithochiton* under kelp-roots at Taieri Beach; these were very like *O. neglectus* (Rochebrune) in shape and sculpture, but were uniformly chocolate in colour, with indications of white patches on the ridge. It seemed highly probable that these were Iredale's "unnamed species." To settle this point the shells were sent to Mr. W. R. B. Oliver, who kindly compared them with the type of *O. subantarcticus* Sut. (from the Auckland Islands, coll. Captain Bollons) in the Wanganui Museum, and wrote, "With regard to *O. subantarcticus*, Suter has only one specimen in his collection, and both Mr. Murdoch and myself agreed that it was like yours; I cannot see the difference between the New Zealand and southern shells. But Suter's specimen is small and in bad order, so it is difficult to come to a decision: Iredale has only made a bald statement, so that his account is unsatisfactory." Under these circumstances it does not seem to the writer wise to propose a specific name

for the Taieri Beach shells until they have been compared with better subantarctic specimens and their identity or difference placed beyond doubt. Till this has been done, or till Iredale gives more satisfactory reasons for his action, it seems better to include *O. subantarcticus* Sut. as a part of the Neozelanic main-islands fauna.

Turbonilla (Pyrgolampros) blanda n. sp. (Fig. 4.)

Shell small, subulate, very thin and fragile, subdiaphanous and subperforate. About 26 slender flexuous axial ribs on penultimate whorl, curved slightly outwards medially, vanishing towards aperture on base (though not suddenly truncated), interstices slightly wider. Ribs regularly convex and smooth, but interstices bear very fine and dense radial riblets, about 15 on penultimate whorl, with linear interstices so that the effect of fine beading between the axials is produced. Similar radial sculpture continued on an increasingly finer scale over the whole body-whorl and base; inside aperture riblets are distinctly visible through translucent test, simulating the characteristic appearance of a *Subonoba.* Colour pale horn. Spire acicular, much higher than aperture; protoconch heterostophe. Whorls 9, regularly increasing, lowly convex with deeply-cut-in sutures, base flatly convex. Aperture subrectangular, angled above, rounded and slightly effuse below. Peristome discontinuous, thin and sharp. Columella slightly arcuate, glossy; inner lip slightly reflexed, leaving narrow umbilical perforation.

Height, 3 mm : width, 0·7 mm.

Type in the author's collection.

Hab.—Taieri Beach, a few miles south of the Taieri River, in seaweed-washings—a single specimen.

Remarks.- The subgenus *Pyrgolampros* is new to our Recent fauna. The Miocene shell, *T.* (*Pyrgiscus*) *oamarutica* Suter, which is a much larger, more stoutly built shell, with very much coarser sculpture, should not be referred to this family at all, as stated elsewhere in this volume (p. 506). There are, however, several new Miocene species of *Pyrgiscus* and *Pyrgolampros* to be described, and some of these are fairly close allies of the present form.

Laevilitorina micra n. sp. (Fig. 5.)

Shell minute, turbinate, rimate, smooth, fragile. Fine curved growth-lines distinct, otherwise smooth. Colour light brown to pale horn. Epidermis shining. Spire conical, lower than aperture, outlines convex. Protoconch very minute, helicoid. Whorls about 3, strongly convex, the last large, base rounded. Suture subcanaliculate. Aperture almost oval, angled above. Peristome sharp, thin, continuous, part of it being the relatively thick parietal callus. Basal lip hardly reflected. Columella arcuate, brown. Umbilical chink distinct, widely funicular. Operculum as in *Melarhaphe*, nucleus near centre of inner margin.

Diameter, 0·7 mm.; height, 0·7 mm.

Type in the author's collection.

Hab.—Taieri Beach, in seaweed-washings—four specimens.

Remarks.—Somewhat allied to *L. antipodum* Filhol, but differing from that species in its lower spire, fewer whorls, and consequently much smaller shell, and more globose shape.

Laevilitorina cystophora n. sp. (Figs. 6, 7.)

Shell very small, subglobose, subperforate, smooth, thin and fragile. Sculpture of growth lines only. Colour fuscous, horny near aperture, epidermis not shining; shell generally overlaid with rusty-brown granulose coating, obscuring upper whorls. Spire very short, obtuse, about one-third of aperture. Protoconch minute, flat, eroded. Whorls about 2, disproportionately increasing, convex, the last very large, base rounded. Suture viewed from above narrowly canaliculate, in other positions inconspicuous. Aperture pear-shaped, not quite symmetrical, fuscous. Peristome continuous, thin and sharp, parietal callus distinct Columella arcuate, faintly twisted, hardly callous. Umbilicus often obsolete, at most only a narrow chink, no carina surrounding it. Operculum normal.

Diameter, 0·9 mm.; height, 1 mm.

Type in the author's collection.

Hab.—Taieri Beach, in seaweed-washings; very common on *Cystophora* to the exclusion of almost all other forms, rare elsewhere. A few specimens were also obtained in seaweed-washings from Breaker Bay, Wellington, so that the species, though hitherto unobserved, is widely distributed.

Remarks. A close ally of *L. hamiltoni* E. A. Smith, from which it differs in the consistently much smaller size, more pear-shaped aperture, and absence of a basal keel round the chink-like umbilicus. From *L. micra* it differs in its larger size, more globose form, much shorter spire, flatter whorls, and absence of a distinct umbilicus.

Verconella compta n. sp. (Plate 52, fig. 2.)

Shell small, fusiform, elongate (especially anteriorly), with bluntly-shouldered whorls, axially and spirally sculptured. Axial ribs prominent on all whorls, beginning to fade out only at a short distance from aperture, 16-17 per whorl, very narrowly convex, interstices up to twice their width, they reach lower suture on spire-whorls, but not upper, disappearing halfway across shoulder, on body-whorl practically confined to periphery, base having only spiral sculpture. This consists on spire and body-whorls of low regular rounded ribs, subequal interstices with a single much finer but otherwise similar rib; the same sculpture continues over canal. Sculpture alters slightly on shoulder; between suture and first regular spiral are 2 similar but more distant spirals, and spaces between these bear about 3 fine riblets. Colour uniformly pale brown; aperture white and glossy; inner lip with red-brown tinge. Spire conical, a little over height of aperture plus canal, outlines straight. Protoconch small, of little over 2 whorls, volutions and nucleus distinct, slightly askew, horny-coloured and minutely granulate; axial acceleration is shown and axials develop in brephic stage before spirals. Whorls about 7½, disproportionately increasing (body-whorl swollen), bluntly shouldered above middle, shoulder strongly sloping and very little concave, then dropping in from vertical to lower suture; base not much excavated, regularly rounded. Suture rather inconspicuous, due to whorl below being prominently flattened upwards to clasp whorl above. Aperture a little oblique, quadrately pyriform, angled and slightly channelled above, with very long canal below; this is flexed to left and slightly backwards, narrowed medially by encroachment of inner lip but opened out near its rounded base. Outer lip strongly swelled outwards, subquadrate, sharply edged and but faintly lirate within; it projects farthest near its base, and on shoulder is considerably cut in to form a wide sinus

also faintly shown on earlier whorls by growth-lines. Columella considerably excavated and twisted below, leading to the apparent formation of a long narrow elevated plait bordering canal. Inner lip spread as a sharply marked thin glaze beyond pillar and upon parietal wall, narrowed to a point below. Operculum not seen.

Height, 38 mm.; width, 15 mm. Height of aperture with canal, 25 mm.; canal, about 12 mm.

Holotype (dredged by Mr. W. La Roche in 20 fathoms off Opotiki, Bay of Plenty) in the author's collection.

This shell has the dimensions of *V. caudata* Q. & G., but differs totally in the shape of its whorls and canal. From *V. mandarina* Duclos it differs in spiral sculpture and relatively much lower spire. Its nearest ally is *V. marshalli* Murdoch, described also in this volume (p. 159), from which it is separable by its sutural flattening, differently shaped whorls, different sinus, longer canal, and slightly different protoconch. A fossil specimen of this species, from Castlecliff, is figured for comparison with the new species (Plate 52, fig. 1).

Note on **Phalium labiatum** (Perry) and its subsp. **pyrum** (Lamk.).

On page 312 of Suter's *Manual of the New Zealand Mollusca* our two well-known Cassids are given the above names, but in the "Emendations" (p. 1084) a change from *P. labiatum* (Perry) to *P. achatinum* (Lamk.) is advocated on the ground that *labiatum* was preoccupied by Chemnitz. Since, however, Chemnitz did not adopt binomial nomenclature, his work cannot affect names that were validly proposed later, so that *P. labiatum* (Perry) should stand.

It seems best to the writer to give the "*pyrum*" form specific rank. This course is adopted by Hedley and May in Australia, and might with advantage be adopted in New Zealand. Hedley also prefers to use the name *Cassidea* generically. The shells differ considerably at sight, and, though they are obviously nearly related, the differences of form and occurrence seem to be of specific importance. Several of the characters of difference given by Suter are variable, but others are constant in all specimens seen by the author. The height of spire in typical forms is much less than in *C. labiata* (Perry) and its angle consequently greater, but this is variable and specimens with moderately high spires are sometimes seen. The shell attains a considerably larger size, is thinner, and always more inflated. Nodulous keels are generally a strong feature of the sculpture, and though these are occasionally absent the spire-whorls are nearly always keeled. The basal spiral grooves may be very distinct or subobsolete (though never totally absent), but the grooves between periphery and suture above are always very distinct. *C. labiata* (Perry) also has often spiral grooves on the base, but fewer in number and much less distinct; infrasutural grooves are absent. The place of denticles on the lower part of the inner lip is taken in *C. pyra* by shallow and indistinct crenulations, the ends of faint furrows following the spiral grooves of the exterior. One of the best and most constant distinguishing points is the character of the umbilicus, which in *C. labiata* (Perry) is narrow and partially closed up by the very small plate formed by the inner lip, while in *C. pyra* (Lamk.) it is wide open and the plate is very large and not encroaching. *C. pyra* (Lamk.) has a wider geographical range than *C. labiata* (Perry); also in New Zealand *C. labiata* (Perry) has not yet been found fossil, while a shell similar to *C. pyra* (Lamk.) is not uncommon in

Pliocene beds, and the still earlier *C. fibrata* (M. & M.) is much closer to *C. pyra* than to *C. labiata*. The separation of these two as species seems therefore justified.

Hedley (*Biol. Res.* "*Endeavour*," vol. 2, pt. 2, p. 68) has described a species as *Cassidea stadialis*, commenting on its resemblance to *C. pyra* (Lamk.) and *C. turgida* (Reeve). The writer was lately fortunate in obtaining several fine specimens of Hedley's species from off Otago Heads, but, as in the case of *Charonia euclia* Hedley, in much shallower water than the Australian type. As Hedley's account is not easily available, and these Cassids are such variable and similar forms, a full description and figures of the New Zealand shells are here given:

Cassidea stadialis Hedley. (Plate 52, figs. 3*a*, 3*b*, 3*c*.)

Shell large, inflated, thin, almost smooth. Whorls 8, always strongly and regularly convex, never angled; much inflated, especially near the base; keels obsolete (but traces are sometimes barely visible on parts of the body-whorl). Reticulation present on upper whorls, but nodules never developed. One or two wide shallow and distant grooves just below suture on the lower whorls, with additional fainter and linear grooves below these on upper whorls. Base quite destitute of grooves; the whole surface covered, as in *P. labiatum* (Perry) and *P. pyrum* (Lamk.), with extremely fine and dense spirals. One of the specimens has a strong varix marking the position of a former outer lip, at about 240° from the mouth of the shell; this is abnormal for *Cassidea*. Colour very distinctive and striking. The whole shell is a uniform glossy fawn-amber tint, suffused with orange or pink. Bands of darker colour are practically absent, and when present number about four and are distinct only near the outer lip; spots are never present. The interior is of the same colour as the exterior with a few milky patches, very highly polished and in places opaline. Outer lip china-white inside, the edge sometimes with 4 dark patches marking the position of the bands. Height of spire variable, but generally well over one-third height of aperture. Protoconch small, obtuse, not sharply marked off. Aperture and columella normal. Outer lip thin, quite smooth, no trace of denticles or furrows on its lower part. Umbilicus, as in *C. pyra* (Lamk.), widely open, due to the extension of the inner lip as a thick twisted plate some distance beyond the columella.

Diameter, 60 mm., 54 mm., 61 mm., 60 mm.; height, 91 mm., 88 mm., 85 mm., 93 mm.; height of aperture, 64 mm., 63 mm., 65 mm., 68 mm

Four specimens in the author's collection, one in the Otago Museum, trawled in about 20 fathoms between Otago Heads and Waikouaiti.

This large and beautiful shell is a noteworthy addition to our fauna. The five specimens were presented to the author by the fisherman who obtained them in the living state, and the following account was given of their capture: Several years ago, while the trawl-boats were at work, the nets were brought up laden with these shells, the sea-bottom being evidently thick with them. The men rightly deemed this strange, as they had never seen them before, and specimens were taken home as curios. Most of these have by this time probably been lost or dispersed, and the author was fortunate in securing the last remnant of the considerable number once possessed by the donor. The species was never found again, possibly because the remainder retreated to the deep water which, in Australia, seems to be the natural habitat of the species. The sudden swarm in

shallower water, with the subsequent disappearance, may be due to pursuit of food, or perchance a new danger that assailed them. Whatever the cause, the shell is probably very rare in New Zealand, though the writer has seen a specimen from the collection of Mr. A. W. B. Powell, of Auckland, dredged in 25–30 fathoms in the Bay of Plenty, where the shell may perhaps be less rare. The species is easily distinguished from *C. labiata* (Perry), which it resembles in smoothness, by its widely open umbilicus; much larger, more inflated, and thinner test; total absence of keels and nodules, and presence of deep infrasutural spiral grooves; and total absence of denticles on the outer lip. From *C. pyra* (Lamk.), to which it is more nearly allied, it differs in its rather greater size and thinner shell; its regularly convex whorls, without nodules, its simpler spiral sculpture and total absence of basal grooves and crenulations of the outer lip; the higher spire (ratio height of spire to height of aperture in the four shells measured is ·31, ·37, ·39, ·42, while the maximum ratio observed in *C. pyra* is under ⅓); characteristic colour, and the disposition of the canal, which is not cut back nearly so far nor so much recurved, is wider, and has its termination squarish instead of rounded.

The Family Liotiidae, Iredale, in the New Zealand Tertiary: Part 1, the Genus Brookula.

By H. J. Finlay, M.Sc., Edmond Fellow of Otago University.

[*Read before the Otago Institute, 12th December, 1922; received by Editor, 31st December, 1923; issued separately, 30th July, 1924.*]

Plate 53.

The shell recorded by Suter as *Lissospira corulum* (Hutt.) is a rather common fossil in the Castlecliff beds, and was originally described by Hutton (1884) as a Pliocene fossil from that locality under the name of *Scalaria corulum* (Hutt.). Subsequently it was discovered to be a still-living form, and was placed, together with another Recent minute shell, in the genus *Lissospira* (Suter, 1913), after a temporary classification in *Cyclostrema* (Suter, 1910). Iredale (1915) rejected these genera as inapplicable to Neozelanic shells, and placed Hutton's species in his genus *Brookula*, with genotype *B. stibarochila* Iredale from the Kermedec Islands (Iredale, 1912). *B. corulum* (Hutt.) is, however, not a typical member of this genus: the elevated spire and somewhat smooth base are abnormal. Iredale (1915) has also proposed the genus *Liotella* to contain such forms as Suter's *Liotia polypleura* Hedley, *L. rotula* Suter, and (?) *Cyclostremella neozelanica* Suter, and the exact difference between *Liotella* and *Brookula* is not very clear. The author at first hesitated to refer all the following species to *Brookula*, but after a discussion of the question with Mr. W. R. B. Oliver, of the Dominion Museum, that course was adopted, it being assumed that *Liotella* should be restricted to subdiscoidal forms.

Apart from *B. corulum* (Hutt.) no others of the genus have up till now been recorded from our Tertiary beds; six new species are here proposed. Specimens are often by no means uncommon in washings and sievings;

the most prolific localities found were Castlecliff, and especially Pukeuri, where four species occur.

Brookula fossilis n. sp. (Plate 53, figs. 4*a*, 4*b*, 4*c*.)

Description of Holotype.—Shell very small, turbinate, perforate, translucent, shining. Whorls 3½, convex, periphery regularly rounded, ornamented with rather prominent and blunt axial ribs, a little unevenly spread and numbering 25 on body-whorl; they remain of same width over the whole whorl, but about half-way across rounded base begin to taper and gradually thin out into umbilicus, which they enter with uniform curve. Interstices only slightly wider than ribs, and show faint traces of spiral striation. Spire very slightly higher than aperture, outlines faintly convex, angle approximately 90°. Protoconch of 1 small globose whorl, distinctly separated from sculptured whorls. Suture deep. Aperture subcircular, very faintly angled above, peristome continuous, columella arcuate. Umbilicus not deep, about one-third width of aperture, only slightly encroached on by columella.

Height, 1 mm.; diameter, 1 mm.

Holotype and five paratypes, from Castlecliff, in author's collection.

Examples seen are very constant, but axials vary from 22 to 25, generally about 24, and interstices are sometimes wider than on holotype, exceptionally reaching 2½ times width of ribs. As far as can be seen from figure, the shell found in a dredging from 15′ S. of Big King Island, in 98 fathoms, and listed by Miss Mestayer (1916) as "*Brookula* sp.," is very close to, if not identical with, this species. This is not surprising, as so many of the Castlecliff shells also occur Recent. More and better specimens of the Recent shell may turn up some day and allow of actual comparison; till then it seems better to regard this species as also of Recent occurrence.

The only Castlecliff form with which this shell can be confused is a shell described later in this paper as *Brookula funiculata* n. sp. At first sight they are much alike, but careful scrutiny shows that *B. fossilis* has a higher spire with lower and more numerous ribs, which are not so evanescent on apical whorls, which in turn are not so discoidal and have a more globose protoconch. The faint circumumbilical keel and sudden change in ribs at this point, characteristic of *B. funiculata*, is wanting in *B. fossilis*.

B. fossilis is readily distinguished from the new species of *Brookula* from Pukeuri (described later) in being much smaller, and possessing much blunter less-prominent axials, and only faint traces of spirals.

Of Recent Neozelanic shells the nearest species is *B. corulum* (Hutt.), which differs in its more turbinate form, its spire being 1½ or more times height of aperture, angle about 50°; in its aperture being more oval, with inner lip encroaching much more on small chink-like umbilicus; and in its more inconspicuous sculpture, axials being much fainter and flatter, prominent only above periphery, after which they suddenly diminish and are so little prominent on base that it seems at first quite smooth; interstices vary from about half to a little more than width of ribs, and are crossed by fairly fine spirals, which, however, are much more prominent than in *B. fossilis*, and hence easily seen.

Brookula iredalei n. sp. (Plate 53, figs. 2*a*, 2*b*, 2*c*.)

Description of Holotype.—Shell minute, but fairly large for the genus, elevated turbinate, perforate, translucent, shining. Whorls 4, convex, periphery regularly rounded, ornamented with fine sharp and prominent

axial ribs, slightly sinuated, generally in three places, and retrocurrent towards umbilicus; there are 24 per whorl on holotype, 27, 25, 26 on others, interstices 2–3 times their width, delicately spirally striate, threads linear, with wide interstices; neither spirals nor axials decrease in prominence on base (as in *B. corulum* Hutt.), but fade gradually into umbilicus. Spire about same height as aperture, outline straight (angle about 70°), whorls 4 (1⅓ of which form the smooth, globose protoconch), convex, periphery and base regularly rounded. Suture deep. Aperture roundly ovate, bluntly angled above. Peristome and columella as in *B. corulum* (Hutt.). Umbilicus distinct, about one-sixth of minor diameter, chink-like, partly hidden by inner lip.

Height, 1·6 mm.; width, 1·5 mm.

Holotype and six paratypes, from Pukeuri, in the author's collection.

In spiral and axial sculpture no difference can be seen between this shell and *B. pukeuriensis* n. sp. (described below), but it is readily separated from it by its non-subdiscoidal upper whorls (*i.e.*, its spire-angle is constant and whorl-increase regular) and by its umbilicus, which is not round and open but more like that of *B. corulum* (Hutt.). The only other species *B. iredalei* resembles is *B. corulum* (Hutt.); but that shell is smaller, with lightly convex spire (angle about 45°), has much lower blunter and more inconspicuous axials, very much less prominent on base, interstices hardly wider than ribs; its spirals are much coarser and flatter, about half width of axials, separated by linear interstices; and its umbilicus is considerably narrower and less prominent.

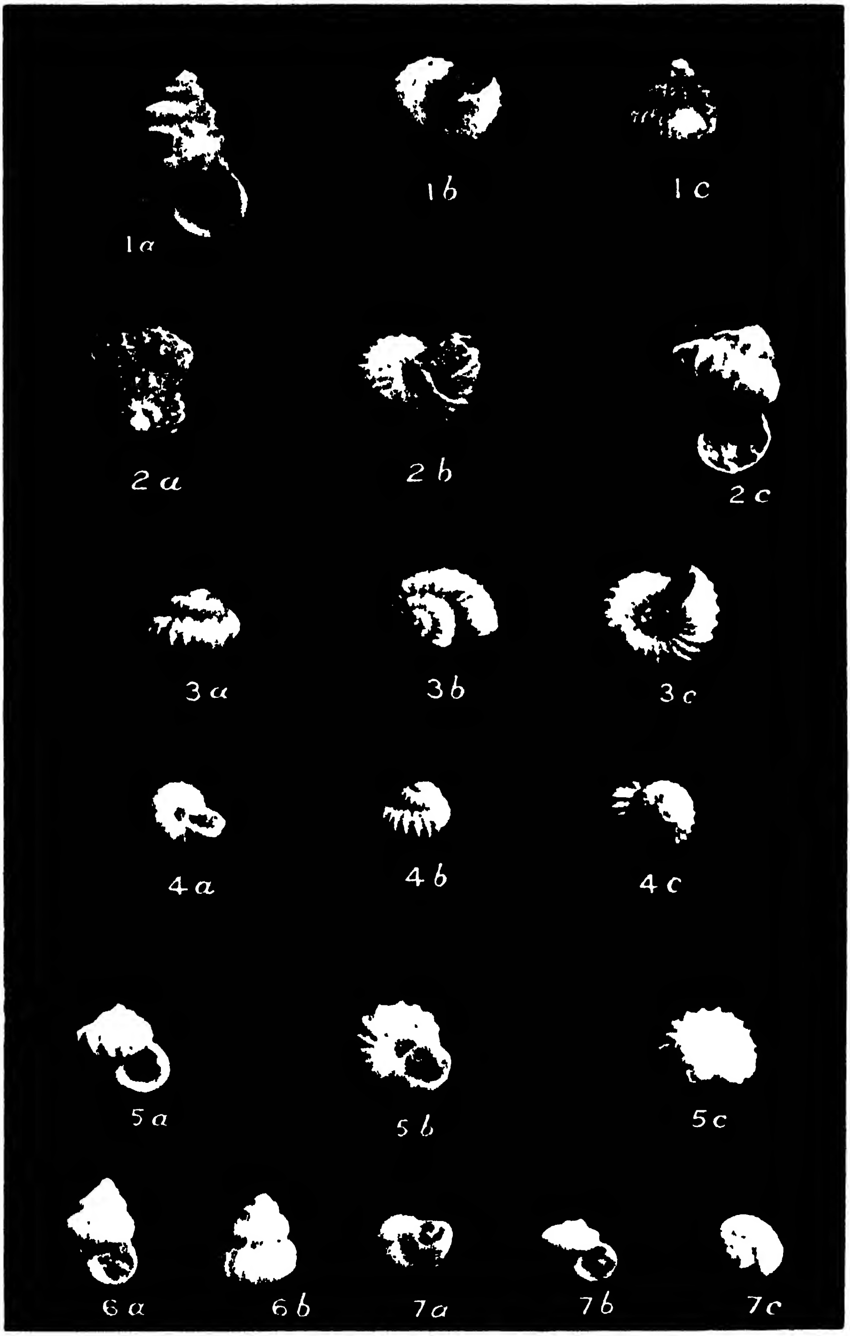
Brookula tenuilirata n. sp. (Plate 53, figs. 1*a*, 1*b*, 1*c*.)

Shell minute but rather large for the genus, elevated-turbinate, thin, perforate, translucent, shining. Axials 42 on the last whorl, the last 12 getting more and more crowded. Two other adult examples have respectively 43, with the last 15 crowded, and 41, with the last 12 crowded. Axials thin and sharp, very similar to those in *B. iredalei* n. sp. (v.s.), but lower, more crowded together, and generally less conspicuous. Exceedingly fine sharp linear spirals, with wide interstices crossing gaps between axials, which are considerably less prominent on base and taper off gradually to vanish in umbilicus; spire conical, almost twice height of aperture, outlines almost straight, angle about 50°. Protoconch of a little over 1 whorl—its nuclear volutions, however, are very obscure—smooth, globose, and fairly prominent, moderately well marked off from embryonic whorls. Whorls lowly convex, periphery and base rounded. Suture moderately impressed. Aperture almost circular, faintly angled above, peristome continuous, columella arcuate, very little expanded. Perforation a moderately deep chink, less than half the size of that in *B. iredalei* n. sp., considerably encroached on and hidden by the columella.

Height, 2 mm.; diameter, 1·5 mm.

Holotype and four paratypes, from Pukeuri, in the author's collection.

This shell differs from *B. iredalei* mainly in its taller spire, less convex outline of whorls, and greater number of axials. In some respects—*e.g.*, shape, convexity of whorls, prominence of sculpture, and size and shape of umbilicus it stands between *B. iredalei* and *B. corulum* (Hutt.); especially reminiscent of the latter is the obsolescence of the axial sculpture on base. The spiral threads are rather more prominent than in *B. iredalei*, especially on base; they are also closer together on whorls, but wider apart on base than in *B. iredalei*.



FIGS 1a, 1b, 1c.—*Brookula tenuilirata* n. sp.
FIGS 2a, 2b, 2c.—*Brookula iredalei* n. sp.
FIGS. 3a, 3b, 3c.—*Brookula pukeuriensis* n. sp.
FIGS. 4a, 4b, 4c.—*Brookula fossilis* n. sp.
FIGS. 5a, 5b, 5c.—*Brookula funiculata* n. sp.
FIGS. 6a, 6b. *Brookula corulum* Hutt.
FIGS. 7a, 7b, 7c.—*Brookula endodonta* n. sp.

All figs. × about 12.

Face p. 528.]

Brookula funiculata n. sp. (Plate 53, figs. 5*a*, 5*b*, 5*c*.)

Shell minute, thin but not very fragile, depressed-turbinate (same general outlines as *Liotella polypleura* (Hedley)), perforate, 20 axials on last whorl, the last five being much more crowded; they are thick and prominent, almost straight but sloping slightly backwards, a little sinuated on base; interstices of variable width, usually 1½–2 times width of ribs. They contain exceedingly fine and generally very faint spirals, low and rounded, only a small fraction of axials in width, interstices linear. The axials continue very prominent on base till about two-thirds across, when they suddenly diminish in width and height and turn in towards umbilicus, thus marking off the edge of a funicle surrounding umbilicus, and this edge, though often very indistinct, is never wholly wanting; it is most prominent on juvenile shells. The funicle is about one-third the major diameter, and at its bottom lies umbilical perforation, which is moderately deep and rather irregular in outline, markedly encroached on by inner lip; it is about one-quarter the width of funicle, and is distinctly lateral, there being a much longer funicular slope towards aperture than elsewhere. After about 1½ whorls from aperture axials very rapidly become obsolete, so that protoconch (1¼ smooth globular whorls) is only indistinctly marked off from following whorl. Spire approximately the same height as aperture, lightly convex, angle about 90° or more. Whorls 3¼, regularly increasing, not tightly wound, but not so loose as in *Liotella polypleura* (Hedley), body-whorl and base narrowly convex; upper whorls being raised, a view from above showing a strongly turbinate shape. Suture deep. Aperture almost free, subcircular, with faint rounded angulation above, peristome continuous, columella arcuate, not reflexed.

Holotype: Height, 0·8 mm.; length, 1 mm. Largest specimen: Height, 0·95 mm.; length, 1·2 mm.

Holotype and about forty paratypes, from Castlecliff, in the author's collection.

Axial ribs generally number 20, but sometimes fall to 17 or 18, due to non-development of crowded anterior ribs. Sometimes axials are thinner, so that interstices may be up to three times their width. This shell has much resemblance to some species of *Liotella*; it differs from *L. polypleura* (Hedley) in details of aperture, axial ribs, interstices, and umbilicus, and from *L. rotula* (Suter) in turbinate shape and different umbilicus. Also related to shell next described. The record of *L. polypleura* (Hedley) from Castlecliff beds possibly refers to this species. The author has examined a considerable number of Wanganui minutiae, and, though this *Brookula* is common (though only in occasional patches, especially in the matrix round corals), no specimens of true *Liotella* or *Liotina* have yet been found.

Brookula pukeuriensis n. sp. (Plate 53, figs. 3*a*, 3*b*, 3*c*.)

Shell minute, very thin and fragile, turbinate, perforate, 23 axials on last whorl in each of the three shells examined, prominent but thin and sharp, curved forward on periphery, slightly sinuate on base; interstices 3–4 times their width, with very fine and linear spirals, interstices again about 3–4 times their width. The spiral sculpture is much more conspicuous than in *B. funiculata*. Axials not obsolete on upper whorls but distinct and sharp directly after protoconch; they pass over base and thin out quite regularly on nearing umbilicus. Perforation semi-perspective, without surrounding funicle; its circular outline hardly interrupted by inner lip, central, and about one-quarter of major diameter. Spire about the same height as aperture, its angle a little less than 90°. Whorls 4,

(protoconch 1½, distinctly marked off); upper whorls rather discoidal, the shell appearing wheel-like from above. Suture deep. Aperture almost free, subcircular, peristôme continuous, columella arcuate, not reflexed.

Height, 1·1 mm.; length, 1·35 mm.

Holotype and about thirty paratypes, from Pukeuri, in the author's collection. Also found at Ardgowan and Target Gully, but not nearly so plentiful.

In its depressed form this shell resembles *B. funiculata*, but is amply distinguished by its altogether more delicate appearance, absence of umbilical keel, and several other details. It may be noted that its whorls descend much more rapidly than in the Pliocene shell, so that although its protoconch is less raised above the encircling whorl the penultimate whorl is much more prominent than in *B. funiculata*. In this it closely accords with the type of the genus, *B. stibarochila* Iredale, and except for its much more delicate facies and more depressed form it is extremely like this species.

Brookula endodonta n. sp. (Plate 53, figs. 7*a*, 7*b*, 7*c*.)

Shell minute, thin, depressed-turbinate, perforate. About 30 rounded axial ribs on last whorl, a little more crowded on earlier whorls, interstices equal to or slightly greater than ribs. Spirals exceedingly fine, subequal to interstices, more distinct than in *B. funiculata* but less so than in *B. pukeuriensis*. Axials ribs flattened down a little on base, and this, together with their greater number, gives base of this species a much smoother appearance than in *B. pukeuriensis*; but in other shell details *e.g.*, umbilicus, aperture, suture there is practically no difference between the two species. The spire is, however, rather lower, body-whorl more regularly rounded, and protoconch (1¼ whorls) slightly smaller.

Height, 0·7 mm.; length, 0·9 mm. Height, 0·9 mm.; length, 1·2 mm.

Types (two almost perfect juvenile shells) and six patatypes, from Target Gully, in the author's collection; also one specimen from Pukeuri. One fragment also from Clifden, Southland (horizon 6 of Park, 1921).

None of the adult shells are complete, but some of the juveniles are nearly perfect; practically all possess 30 axial ribs per whorl. The species is very close to *B. pukeuriensis*, differing mainly in its more depressed shape and greater number of axials, resulting in much closer and finer ribbing.

Of the species of *Brookula*, three (*B. fossilis*, *B. corulum*, and *B. funiculata*) seem to be restricted to the Pliocene, while of the four Miocene species only two have so far been found at more than one locality; the range of species seems therefore to be small, and they should prove of considerable use. The author regrets that he has had no opportunity of examining much shell-sand from horizons between the Awamoan and Castlecliffian; probably several more new forms would be found in such beds, as there is rather a wide evolutionary gap between the Pliocene and Miocene forms here described.

A rather curious point is that these Miocene species are more typical Brookulas than the three Pliocene forms. Although the name *Brookula* is used for all these species, they are easily divisible into two groups, one being typified by an elevated-turbinate shell with regular whorl-growth, constant spire-angle, and usually narrow umbilicus, and the other by a depressed-turbinate shell with subdiscoidal early whorls, leading to a continued decrease in spire-angle with growth, and a rather wide and prominent umbilicus.

The type of the genus, *B. stibarochila* Iredale, though rather elevated, evidently belongs to the second group. Mr. W. R. B. Oliver kindly presented the author with an authentic specimen of the type species, and an examination of this shows that, of the shells mentioned in this paper, the nearest to the type is *B. pukeuriensis*. This, however, is easily distinguished by its more fragile test, much more delicate and more numerous ribs, and more depressed shape. *B. stibarochila* Iredale has a variable number of coarse, prominent, rounded ribs (15 on the last whorl of the type, 19 in the author's specimen. Oliver (1914) remarks that "specimens vary considerably in the number of ribs; the type has them wide apart"), but its base is regularly convex, the ribs thinning down gradually into the deep, narrowly circular perforation. The author here proposes the new subgeneric name *Aequispirella* to cover the forms of the first group, naming as type *Scalaria corulum* Hutt.

Subgenus AEQUISPIRELLA n. subgen.

Shell minute, similar to *Brookula* s. str. except that early whorls are not depressed—*i.e.*, protoconch is prominent and raised instead of inconspicuous and discoidal. This imparts to spire the shape of a cone instead of a dome, and leads to much more regular whorl-growth than in *Brookula* s. str.; shell generally more elevated. Umbilicus generally much narrower and less prominent than in the strict forms, being often chink-like, and the axial sculpture sometimes becomes obsolete on base.

Type: *Scalaria corulum* Hutt. (Plate 53, figs. 6*a*, 6*b*.)

KEY TO SPECIES.

Shell depressed-turbinate (*Brookula* s. str.).
- Shell fairly strong, with a subobsolete umbilical keel, 20 axials per whorl .. .. *B. funiculata.*
- Shell fragile, with no umbilical keel.
  - About 23 thin and sharp axials on last whorl, interstices 3–4 times their width .. .. .. *B. pukeuriensis.*
  - About 30 rounded axials on last whorl, subequal to their interstices .. .. *B. endodonta.*

Shell elevated-turbinate (*Aequispirella*).
- Axial ribs considerably diminished in prominence on base.
  - Over 40 axials on last whorl .. .. .. *B. tenuilirata.*
  - Under 30 axials on last whorl .. .. .. *B. corulum.*
- Axial ribs not diminished in prominence on base.
  - Axials thin and sharp, spirals generally distinct .. *B. iredalei.*
  - Axials rather blunt; spirals very faint .. .. *B. fossilis.*

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Two New Species of Magadina.

By H. J. Finlay, M.Sc., Edmond Fellow of Otago University.

[*Read before the Otago Institute, 11th December, 1923; received by Editor, 31st December, 1923; issued separately, 30th July, 1924.*]

The two species here described are close relatives of *M. browni* Thomson (*Trans. N.Z. Inst.*, vol. 47, pp. 399, 402, 1915), but in general shape and inflation somewhat intermediate between that species and such Australian forms as *M. compta* (Sow.) and *M. cumingi* (Davidson). They both occur at the same locality, but in beds of slightly different age; these beds are, however, probably of approximately the same age as those from which the only two other New Zealand species have been obtained—viz., *M. browni* Thomson and *M. waiparaensis* Thomson but the locality is much farther south. Thomson (*loc. cit.*, vol. 52, p. 369, 1920) has indicated the existence of a third species, and this may possibly belong to one of the present forms.

Magadina clifdenensis n. sp. (Fig. 1.)

Shell small, sub-shield-shaped, longer than wide, greatest breadth just below hinge-line; sides at first gently curved, but curve rapidly increasing anteriorly and then diminishing quickly, giving rise to a marked taper; hinge-line still straighter than in *M. browni*; dorsal valve very lightly convex, with a long, narrow, and increasingly pronounced anterior sinus, having the appearance of a shallow trough traversing half the shell; ventral valve highly raised, very strongly but bluntly carinate, the ridge being of regular prominence from inception at beaks to termination at valve-margin, and not noticeably widening over its whole extent; commissures with very strong, narrow, and sudden fold, dorsal valve being much bent inwards in a narrow tongue; beaks short, not incurved, truncated almost horizontally by rather small, elongate-oval foramen, whose rim is not rounded and slightly thickened as in *M. browni*, but thin and sharp, forming with beak-ridges distinct telae; beak-ridges sharp, forming a false area, most of which (more than in *M. browni*) is occupied by a lightly concave pseudo-deltidium. Internally valves agree with *M. browni*, except for the following differences: In dorsal valve socket-ridges are much smaller, relatively less solid, and much closer together, especially posteriorly, where they slant towards each other; they do not end in sharp point, and notch between them, viewed posteriorly, is much narrower; hinge-trough is narrower and deeper, and cardinal process much smaller than in *M. browni*, a fact probably indicative of greater antiquity of present species. Another factor that would support this is that the two branches of loop are more closely cemented to median septum than in *M. browni*—*i.e.*, junction of ascending and descending branches is merged in septum, instead of forming a continuation ridge as in the Waipara species, so that *M. browni* would seem to have a slightly more advanced type of Magadiniform loop than has *M. clifdenensis*. Outline of loops, too, is less circular, and muscular impressions more restricted to upper part of shell. In ventral valve hinge-teeth are much closer and even more strongly

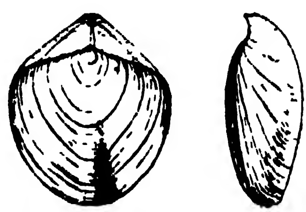

Fig. 1.
Type, *Magadina clifdenensis* n. sp.

bifid. Surface of both valves unsculptured except for growth-lines, but the shell-substance is everywhere elegantly and fairly finely punctate. Thomson has not mentioned this as an attribute of *M. browni*, but it exists in that species, though more difficult to observe on account of the rubbed surface of most specimens; the punctation is slightly finer then in *M. clifdenensis*. Easily distinguished also from *M. browni* by smaller size, narrower and much deeper sinuation, and especially much flatter dorsal valve and more convex and very strongly carinate ventral valve

Holotype Length, 8 mm.; breadth, 7·2 mm; thickness, 3·3 mm.

Paratype Length, 7 mm.; breadth, 6·6 mm.; thickness, 3 mm.

Type and many paratypes, from Clifden, Southland bands 7A (type) and 7B (Hutchinsonian ?) in author's collection.

Magadina thomsoni n. sp. (Fig. 2.)

As in the case of *M. waiparaensis* Thomson (*loc. cit.*, vol. 47, p. 403, 1915), this species is best described by comparison with one nearly related—in this case the previous new species. From this it differs at sight especially in its much smaller size and even flatter dorsal valve, which posteriorly is almost perfectly flat and anteriorly lightly concave. This fact is due to the earlier inception of the median sinus, which noticeably begins to flatten the valve at the upper third of the shell and very rapidly deepens, though remaining only about half the width of that in *M. clifdenensis*. At the anterior end of sinus the valve is sharply bent in as in that species, but tongue is narrower, more pointed, and usually not so long. Beaks are much lower, and margins forming them distinctly concave instead of straight as in the three other New Zealand species; this impression is heightened by greater rounding of margins near hinge, giving the shell a subcircular outline, pointed at both ends. Ventral valve very similar to that of preceding species, but more pointed and less raised anteriorly, with a similar very strong and blunt but slightly narrower carination. Remaining external details, pseudo-deltidium, punctation, &c., approximately the same in the two species. Internally the species are also much alike, but septum dies almost entirely away before reaching socket-ridges, and cardinal process is minute—even smaller than in *M. clifdenensis*. In ventral valve teeth are a little smaller and closer, and anterior median ridge separating muscular impressions is slightly lower.

FIG. 2.
Type, *Magadina thomsoni* n. sp.

Holotype—Length, 5·3 mm.; breadth, 4·9 mm.; thickness, 1·6 mm.

Paratype Length, 5·5 mm.; breadth, 4·7 mm.; thickness, 1·7 mm.

Type and several paratypes, from Clifden, Southland—band 6A (Ototaran ?) in the author's collection. Separate valves are fairly common, but only three perfect specimens have so far been obtained; of these the best preserved is taken as the type, though the ventral valve, as the figure shows, is bent back a little at margin; this is due to accident, and normal specimens have a regularly convex valve as in *M. clifdenensis*.

The species is named in honour of Dr. Thomson, Director of the Dominion Museum, in acknowledgment of much freely-given advice and assistance. Apart from its occurrence in older beds, *M. thomsoni* shows, in its less-developed beaks, its earlier-developed dorsal sinuation, and its more primitive cardinal process, features that stamp it as ancestral to its near relative, *M. clifdenensis*.

Preliminary Note on the Clifden Beds.

By H. J. Finlay, M.Sc., Edmond Fellow of Otago University, and F. H. McDowall, M.Sc., A.I.C.

[*Read before the Otago Institute, 11th December, 1923; received by Editor, 31st December 1923; issued separately, 30th July, 1924.*]

In 1921 Professor Park* published a brief account of some Tertiary localities in Southland. The most important of these so far known is at Clifden, where the Tertiary beds extend for nearly half a mile along the right bank of the Waiau River. Park states that "a rich harvest awaits the collector at Clifden," but also that "no attempt was made to make collections of fossils anywhere." Accordingly a visit was made to this locality in the hope that it might prove of interest, and the results have already far exceeded expectations.

The beds are sometimes a little difficult of access, but the fossil forms obtainable are so new and magnificent, and their preservation so fine, that the labour is well spent. Some four hundred species are now in hand, the majority of which have proved exceptionally interesting. Preliminary study of these forms shows that, though the beds from which they come are younger than the Waiarekan, they are as certainly older than the Awamoan. The very rich fauna and the exceptional preservation make comparison easy, and there is no doubt that the Clifden fauna is a peculiar one, and represents a facies not previously known in New Zealand.

Park has grouped the basal concretionary plant-beds in the Waiarekan; the limestone and overlying glauconitic sandstone in the Ototaran; the four following highly fossilferous sand beds in the Hutchinsonian; and the two highest bands in the Awamoan. No reasons are given for this classification, and it is possible that the fossiliferous beds should be placed in a lower horizon. Much confusion has already resulted in New Zealand from the misuse of palaeontological evidence, and the reliance on lithology alone, and we consider that the only safe guide to the age of many New Zealand beds is the accurate interpretation of their palaeontology. The Clifden beds are certainly puzzling, but the problem of their age seems to admit of only two solutions—*i.e.*, the fossiliferous sands must apparently be treated as either Hutchinsonian or Ototaran—and the hypothesis which seems most reasonable, and demands the fewest assumptions, is the one that must be accepted. If the uppermost Clifden beds be considered as Awamoan, and the intermediate beds as Hutchinsonian, then these horizons apparently contain different faunas in Southland from those they would contain in Oamaru. (It must be mentioned, however, that strong faunal *resemblances* exist—the genera are nearly all the same, though most of the species are different; but this is usual in New Zealand, where there are very few sharp distinctions in the faunas of adjacent horizons.) Though reasons may be invented to support such a possibility, it would, if adopted, allow of unlimited licence in correlating

* J. Park, Geology and Mineral Resources of Western Southland, *N.Z. Geol. Surv. Bull. No. 23 (n.s.)*, pp. 50–52.

geographically distant beds,* and it seems to us preferable to consider that, where the lithological conditions are not totally at variance, different faunas indicate different horizons.

Thus it seems probable that the Awamoan stage in the strict sense— is not represented at all at Clifden. The topmost bed (No. 8 of Park) has, as might be expected, most analogy with the Awamoan, and may possibly be referable to a basal Awamoan stage, such as is represented by the Target Gully and Ardgowan shell-beds, though a definite statement cannot yet be made. It seems, however, almost certain that some of the lower, richly fossiliferous beds should be placed below the Hutchinsonian, the contained fauna being unlike that of beds at present referred to the Hutchinsonian† —*e.g.*, Otiake, Blue Cliffs, Mount Brown, &c.

The importance of this is obvious, no satisfactory store of fossils having previously been discovered in beds of this horizon. The separation between Ototaran and Hutchinsonian at Clifden is not yet clear, though there does not seem to be any reason to doubt the Ototaran age of the limestone itself; in common with the other Ototaran limestones of New Zealand, its molluscan fauna (*Pecten huttoni* Park, *Epitonium lyratum* Zitt., *Chlamys* cf. *burnetti* Zitt.) is of such a nature as to be useless for age-determination, but the brachiopods seem to be Ototaran. It cannot possibly be Atiuan. For the determination of the true ages of all the Clifden beds much will depend on the brachiopods; we have collected specimens from several of the horizons, and have to thank Dr. Thomson for identifying many of them. Some curious correlations are suggested by the brachiopod evidence, but there are several apparently anomalous facts, and consideration of these is withheld till a more complete account can be given.

Unfortunately the beds beneath the limestone seem to be unfossiliferous except for plant-remains, which, in the present state of palaeobotany in New Zealand, are not of great use. On the east coast, at Wangaloa, is a Palaeocene fauna; between this and Clifden, at Chatton, occur shells which have been examined by one of us, and which show that the beds there are almost identical in age with the Wharekuri greensands (though of a more littoral character); at Waikaia are beds (now hidden) perhaps a little

* Dr. Marshall has used this plea when investigating the Pakaurangi Point fauna, and has correlated that locality first with Target Gully (*Trans. N.Z. Inst.*, vol. 49, p. 275, 1917), then with the Oamaru limestone (*loc. cit.*, vol. 50, p. 275, 1918), and finally with the All Day Bay beds - "that is, next above the Oamaru limestone" (*loc. cit.*, vol. 50, p. 276, 1918). Subsequent writers have often assumed those beds to be Awamoan. Their true age cannot be regarded as yet settled, but they are undoubtedly not Awamoan, if by "Awamoan" is meant the horizon of the beds at Awamoa Creek and Pukeuri. The fossils of the Pakaurangi Point beds do not seem like those of Target Gully or Otiake, but have many points in common with those in our Clifden collections, as will be seen from the short list at the end of this paper. There are also a few significant relations with species from the Kakanui tuffs. The Clifden beds provide a nearer approach to the Pakaurangi fauna than does any other horizon at present known, and it seems advisable to treat the Kaipara beds as part of the great Ototaran–Hutchinsonian sequence; it is even possible that they may be older than all the fossiliferous bands at Clifden, and represent part of the stage developed there as limestone or unfossiliferous sands.

† If the name "Hutchinsonian" is to be restricted to a greensand horizon definable by its brachiopods, then a new term will be necessary for beds such as those mentioned, which contain an abundant molluscan fauna. This fauna is of an older type than that found at Target Gully, so that the name "Awamoan" should not be used, there is already too much laxity in the use of that term. Morgan (*Pal. Bull. No. 8*, p. 103) would merge the Hutchinsonian with the Ototaran, but a name is needed for the stage represented at Otiake, and in the meantime it seems preferable to employ one already in use. One of us has in preparation a detailed account of stages separable from the Hutchinsonian and Ototaran, and this matter will then be more fully dealt with.

older than the Chatton sands; and at Pomahaka, not far above the coal-measures, are tuffs containing a very peculiar and apparently brackish-water fauna of about a dozen species, which give no indications of their geological age. Apart from these occurrences, Lower Tertiary beds have not been discovered in Southland; no trace has yet been found of the Bortonian or of the other stages present at Waihao.

Long and tedious work will be necessary before the Clifden faunas can be thoroughly elaborated, and till this is completed only tentative conclusions can be drawn as to their age. If, however, the suggestions here put forward prove correct, it is evident that a rich molluscan fauna already flourished in New Zealand before the Awamoan, and, if one may judge by generic similarities, evidently gave rise to the Awamoan faunas. The range of many genera and some species will be prolonged into Hutchinsonian and perhaps Ototaran times, and this will considerably weaken the theory that a connection with some land-mass at about the Awamoan stage must be postulated to account for the sudden increase in fauna. Writers have commented on the richness of the Awamoan fauna, but even the preliminary collections from Clifden show that the fauna there is equally rich.

There is still, however, the tantalizing stretch of limestone even at Clifden, during whose deposition much faunal change must have occurred. From the thickness of the Clifden section it is evident that the deposition of the Ototaran Hutchinsonian in the Oamaru district must have occupied a very long period of time. Park gives the maximum thickness of the Oamaru stone as 110 ft., and of the Clifden limestone as 160 ft., bands 2 6 occupy another 100 ft., and band 7 is 175 ft. thick. Now, the evolutionary differences shown between successive bands of the fossiliferous beds seem to be quite as great as, for instance, between the Hutchinsonian and basal Awamoan, or Awamoan and Mokauian, so that, the rates of evolution being assumed equal, either these stages represented quite short time-periods, or the Ototaran–Hutchinsonian period, as at present understood, was of considerable duration.

The unfossiliferous nature of the Oamaru stone has been the source of much palaeontological confusion as regards faunas above and below it, and has prevented the clear reading of the evolutionary sequence between our early and middle Tertiary faunas. Although the upper beds at Clifden will materially help in this respect, the thick basal limestone again prevents the complete solution of the problem, and at present we are still left with the apparently sudden appearance above the limestone of a rich and varied fauna, which in some respects is very like, and in others very unlike, that found in pre-Ototaran beds. It can only be said here that a careful comparison of material from Wharekuri, Clifden, and Otiake leaves the impression that the evolution of our fauna proceeded equably throughout the limestone regime, and that if a new fauna did enter by means of a shallow-water connection at that period it scarcely disturbed the hardy pioneers already in possession.

The arrival of a new fauna is generally supposed to imply increased competition, often resulting in extinction of all but the hardiest members of the prior colonists. The weaker members of the invading troop would also often find the changed conditions unfavourable, and would probably perish. This may possibly account for the failure of a large number of apparently newly established species and genera to survive beyond the Awamoan: *e.g.*, *Pollia acuticingulata* (Suter), *Merica brevirostris* (Hutt.), *Hinnites trailli* Hutt., *Erato neozelanica* Suter, &c. At the same time,

there are certain genera, such as *Natica, Turritella, Venericardia, Leucosyrinx, Pseudotoma, Divaricella, Crepidula, Calyptraea,* and many others, which extend in an unbroken evolutionary line of slowly changing species almost throughout our Tertiaries. It is the presence of members of such genera—generally more plentiful than the restricted forms—that gives to successive Tertiary faunas in New Zealand an appearance so strikingly (and deceptively) similar. To this also is due the statement repeatedly made by Marshall* that the ancestral counterpart of any fauna can be found in the one preceding it. This is true for such genera as mentioned above, but unless it is true for all the genera Marshall's argument does not seem to be logical. It is only to be expected that the hardy members of our original fauna would, under conditions of comparative isolation, persist with but little change for a long time; there is no need to insist on absolute isolation. Further, this fraction of our various faunas, though superficially often overwhelming, is the least important, what one must consider most is the residue of short-living species and newly appearing forms. There seems to be no doubt that the ancestors of many forms cannot be traced in earlier horizons, and it is not reasonable to suppose that this is always due to imperfect collecting. As our knowledge stands at present it is impossible to assume that the Clifden fauna was wholly derived from that found in the Waiarekan greensands at McCullough's Bridge, or that that in turn was entirely descended from the Palaeocene fauna of the Wangaloan, though in each case evolution is no doubt responsible for a certain part. The real problem to be solved is the origin of the remainder.

Dr. Marshall has so consistently urged the continual isolation of New Zealand, and the evolution of every fauna from its predecessor, that the time has come when we may expect the pendulum to swing in the opposite direction. Without, however, committing ourselves on the subject, we believe that the molluscan evidence is at present too imperfect to allow of the postulation of definite land connections. Four things must be done before this can be attempted: (1) Revision of the palaeontological work begun by Suter (this will involve the recasting of most of the published lists); (2) very much further collecting and accurate comparison and determination of species; (3) search for missing stages below the Ototaran, and for a fossiliferous facies of the part of that stage known only as "limestone"; (4) more thorough comparison with Australian and South American Tertiary faunas.

In order that our conclusions as to the age of the Clifden beds may be more readily followed, we append a brief list of some of the characteristic forms from band 6. Positive identifications are as yet made in only the few cases where no doubt can exist: "cf." indicates that the shell is very close to the species mentioned, judging from literature, but may be new; "aff." indicates that the species is certainly new, but has its nearest relative in the species mentioned.

We would also like to mention that wherever comparisons with various faunas have been mentioned our conclusions have been drawn from a study of actual specimens; we have at no time relied on lists of fossils from the localities concerned.

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* See, for instance, *Trans. N.Z. Inst.*, vol. 50, p. 277, 1918; vol. 51, p. 244, 1919; vol. 52, p. 126, 1920; and vol. 53, p. 96, 1921. From the last reference the following words may be quoted: "We have, then, been forced to the conclusion that from the time the Wangaloa and Hampden beds were deposited until the present day the marine mollusca of New Zealand have shown a gradual development, without any important additions at any time from other fauna regions."

Shells from Band 6.

Erato aff. n. spp. from Kakanui tuffs and Chatton.
Cypraea aff. *trelissickensis* Suter.
Heliacus aff. *aucklandicus* Marshall.
Galeodea cf. *muricata* (Hect.).
Epitonium cf. *tricinctum* Marshall.
Niso cf. *neozelanica* Suter.
Fusinus several species, aff. *kaiparaensis* Suter, *solidus* Suter, and further n. spp. from Waihao.
Fusinus aff. *climacotus* Suter.
Aethocola aff. *flexuosa* Marshall.
Cominella aff. *carinata* (Hutt.).
Typhis n. sp.
"*Scaphella*" aff. *elegantissima* Suter.
Lyria n. sp.
Ancilla cf. *spinigera* Marshall.
Marginella n. sp. (also from Chatton).
Gemmula cf. *bimarginata* Suter.
Turricula aff. *latescens* (Hutt.).
Bathytoma aff. *haasti* (Hutt.).
Pseudotoma aff. *robusta* (Hutt.).
Pseudotoma excavata (Suter).
Borsonia aff. *rudis* (Hutt.).
Leptoconus cf. *armoricus* Suter; and several other species.
Scaphander aff. n. sp. from Chatton.
Anomia cf. *poculifera* Marshall.
Glycimeris aff. *subglobosa* Suter.
Glycimeris aff. *trelissickensis* Marwick.
Glycimeris aff. n. sp. from Otiake (*laticostata* group).
Chama n. spp.
Pecten aff. n. sp. from Wharekuri.
Propeamusium cf. *zitteli* (Hutt.).
Venericardia subintermedia Suter.*
Protocardia patula (Hutt.).
Macrocallista sculpturata Marshall.
Corbula nitens Marshall.
Tellina cf. *inconspicua* Marshall.

Besides these, there are a few further significant species from other bands, as follows:—

From Bands 7 and 8.

Ampullina cf. n. sp., from the Waihoa greensands.
Natica n. sp. (also from Otiake).
Fusinus aff. *maorium* M. & M.
Ventricola n. sp. (also from Otiake).
Chione cf. n. sp., from Chatton.
Chama huttoni Hect.
Olivella cf. *neozelanica* Hutt.

From Band 4.

Mitrella cf. *inconspicua* Marshall.
Borsonia n. sp.
Turricula aff. *marginalis* Marshall.†

The present paper must be regarded as entirely preliminary; for the moment the various lines of evidence as to the age of these beds conflict so much that a satisfactory solution seems difficult. One fact seems to be clear—that the Awamoan, Hutchinsonian, and possibly Ototaran stages as at present constituted are too comprehensive, and urgently need subdivision before the work of correlation can be carried out properly.

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* The shell described by Dr. Marshall (*Trans. N.Z. Inst.*, vol. 50, p. 272, 1918) as *Cardium* (*Glans*) *kaiparaensis* from Pakaurangi Point is, from the figure and description a juvenile of the shell described by Suter from the same locality as *Venericardia subintermedia*. It is certainly a *Venericardia*, Suter's original naming of Marshall's specimen being *Cardita* (*Glans*), not *Cardium*, and it appears so in the list in *Pal. Bull. No. 8*, p. 3, and in Marshall's own list (*loc. cit.*, p. 274). There are one or two other discrepancies in this list—*e.g.*, *Epitonium tricinctum* Marshall appears as *Epitonium trilineatum* n. sp.; and there are a number of misspellings. *Dentalium pareorense* is quoted as of Ihering (in vol. 51, p. 235, it is referred to Suter), *Cardium pulchellum* Gray appears in place of *Protocardia pulchella* (Gray), and *Epitonium browni* Zitt. is given a place. *Chione auriculata* Bartrum, described from this locality (*Trans. N.Z. Inst.*, vol. 51, p. 97, 1919), is apparently a *Lucinida*, close to *L. laminata* (Hutt.). One of us (*Proc. Mal. Soc.*, vol. 16, 1924) has proposed the name *Chlamys kaiparaensis* Finlay in place of *Pecten subconvexus* Marshall, preoccupied.

† This species belongs to the group containing *torticostata*, *marginalis*, *gravida*, *ordinaria* (all of Marshall), and *hamiltoni* (Hutt.)—a group characteristic of early Tertiary horizons in New Zealand. (See Marshall, *Trans. N.Z. Inst.*, vol. 52, p. 114, 1920.)

Lahillia *and some other Fossils from the Upper Senonian of New Zealand.*

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Communicated by P. G. Morgan.

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Plate 54.

SOME time ago I received for examination from Mr. P. G. Morgan, Director of the Geological Survey, through Mr. J. Marwick, Palaeontologist, some fossils from several localities in the South Island of New Zealand. I am much indebted to Mr. Morgan for the transmission of this interesting material, which was collected at the following localities: 13 (Amuri Bluff, McKay, 1873 and 1876); 22 (Green Island, near Dunedin, McKay, 1873); 589 (Selwyn River Rapids, Malvern Hills, McKay, 1886); 592 (Shag Point, beach near coal-mine and McIntosh's store, McKay, 1886); and 320 (Shag Point, Hector, 1865).

The conclusion reached after an examination of these fossils is that all the localities represented are of Upper Senonian age.

DESCRIPTION OF THE FOSSILS.

LAMELLIBRANCHIATA.

LAHILLIA Cossm.

Lahillia cf. luisa O. Wilck. sp. (Plate 54, figs. 1, 2, 3, 4.)

Outline of shell oval. Umbones very prominent, curving strongly inward and very slightly forward, and situated a little behind middle of dorsal margin. Shell inflated, anterior portion somewhat flatter than posterior and somewhat produced. Anterior margin considerably convex, passing gradually into slightly convex ventral margin. Posterior margin less rounded than anterior and somewhat truncated. Antero-dorsal and postero-dorsal margins concave. Lunule flat. Ornamentation consists of rather coarse concentric ridges at wide intervals, and of thin growth-lines in interspaces, well preserved on ventral portion of shell, while the coarser ribs are less conspicuous in this region. Muscular impressions not visible. One specimen shows portion of ligamental groove (Plate 54, fig. 4).

Hinge of right valve (Plate 54, fig. 3) partly preserved in specimen from Amuri Bluff. As specimen is a rather young individual, hinge is still delicate. Posterior cardinal tooth of rounded-triangular shape and directed downward and forward. Grooves on both sides of this tooth, destined for cardinal teeth of left valve, are more or less well preserved, but lateral teeth are destroyed.

Specimen from locality 589 shows portion of hinge of left valve (Plate 54, fig. 4). In this specimen the considerable thickness of the shell is visible, which is a character of the genus. (It is a consequence of this thickness that umbones of casts are more prominent than those of shells.) Ventral margin of hinge-plate well preserved, but teeth more or less damaged. Most conspicuous is the large groove of triangular outline

destined for posterior cardinal tooth of right valve. Before this large groove is a second but flat one, the posterior two-thirds of which is really base of destroyed anterior cardinal tooth. Behind central groove there ought to be the posterior tooth, but this is no longer present, the weathering of the shell having produced two facets separated by a sharp horizontal edge.

Measurements (in millimetres) :—

	(*a.*)	(*b.*)	(*c.*)
Length	65	70	56
Height	60	63	45
Diameter of both valves.. .. .	36	..	36

(*a.*) Internal cast from locality 592 (Plate 54, fig. 1).

(*b.*) Internal cast from the same locality (Plate 54, fig. 2). Height is that of left valve, of which only dorsal portion is visible in figure.

(*c.*) Internal cast of a young specimen. In young individuals shell is more inflated than in older ones. Dimensions of (*c*) agree well with those of a specimen of *Lahillia luisa* O. Wilck. sp. from South Patagonia (1).

Specimens (*a*) and (*b*) being damaged, their length may be somewhat greater than stated.

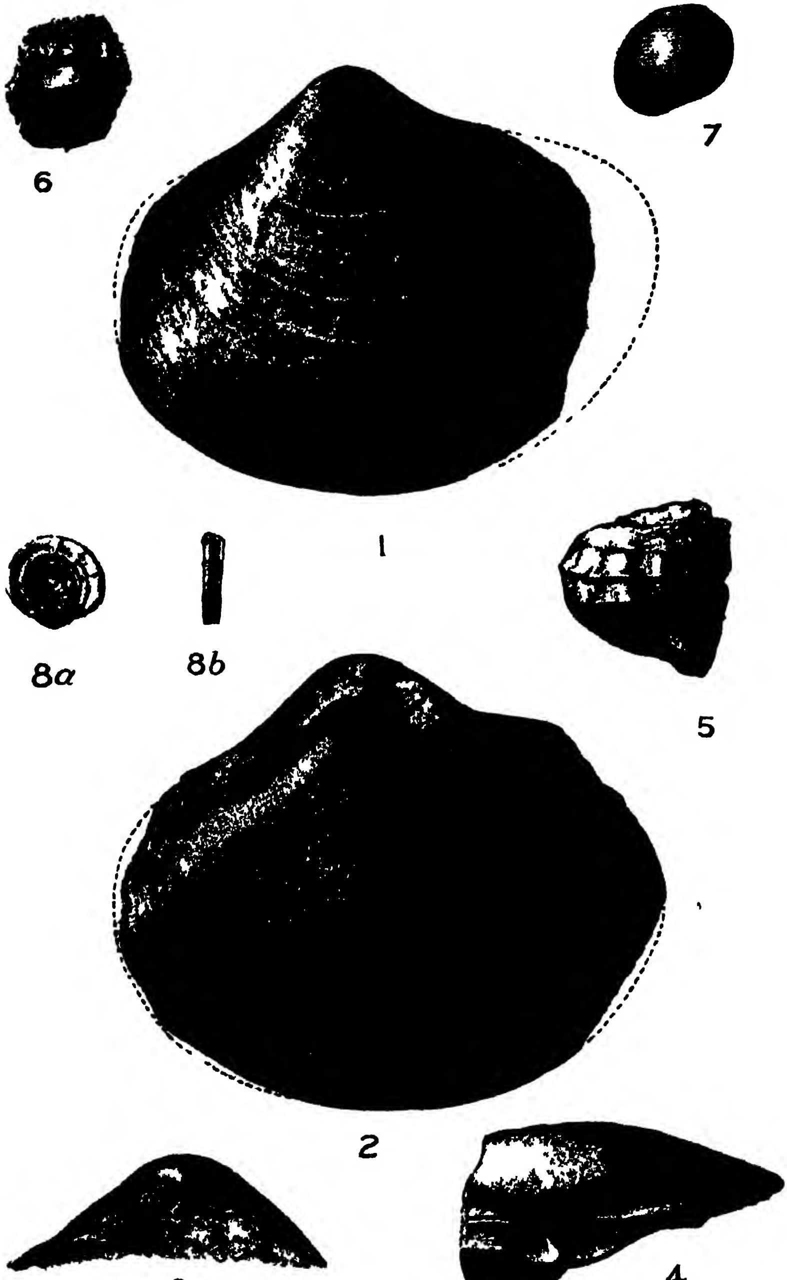
Localities.—(*a*) Shag Point, loc. 592; (*b*) Amuri Bluff, loc. 13; (*c*) Malvern Hills, loc. 589.

Affinities. Undoubtedly the fossils here in question belong to the genus *Lahillia* Cossm. (antea *Amathusia* R. A. Philippi). Other Cretaceous species of this genus are *L. veneriformis* Hupé (2) sp., from the Quiriquina beds of Chile; *L. luisa* O. Wilck. sp., from the Louisa beds of South Patagonia and of the Upper Senonian of Graham Land (Antarctica). These two species are nearly related. The chief differences between them are (i) the form of the hinge-teeth and (ii) the margin of the hinge-plate. The specimens from New Zealand agree best with *Lahillia luisa.* I have not given this name to them without any restriction, because the material is not sufficiently complete. Furthermore, the posterior cardinal tooth of the New Zealand pelecypod is directed obliquely forward and in the Patagonian one obliquely backward. The occurrence of nearly related species of *Lahillia* in the Upper Senonian of New Zealand, Quiriquina, South Patagonia, and Graham Land is another demonstration of the close relations which existed in Upper Senonian times between these regions bordering the present southern Pacific Ocean.

Historical Remarks.- In view of the palaeontological stratigraphical, and palaeogeographical importance of *Lahillia*, it may be advisable to give readers in New Zealand an account of the historical development of our knowledge of this genus.

The first description of a *Lahillia* was that which in 1854 Hupé gave of *L. veneriformis* from the Upper Senonian of the island of Quiriquina, near Concepcion, Chile. Hupé called it *Crassatella.* In 1887 R. A. Philippi gave various specific names to this pelecypod, and placed it in the genus *Mactra: M. tumida, M. ferrieri, M. d'orbignyi, M. pinguis* (3). Moericke (4) described a specimen from Quiriquina under the name *Mactra tumida.* In 1904 I showed (5) that all these species belonged to the genus *Amathusia* R. A. Phil., and that all the species named are to be united under the name of *Amathusia veneriformis* Hupé sp. In 1907 the Upper Senonian of South Patagonia furnished the nearly related species *A. luisa* O. Wilck (6).

The genus *Amathusia* was established by Philippi for two species from the Chilian Tertiary (7); von Ihering (8) and Ortmann (9) described it from the Tertiary of Patagonia. The name *Amathusia* being preoccupied, Cossmann introduced the name *Iheringia* for the genus, and, as this name was also preoccupied, *Lahillia* (10).



FIGS. 1–4.—*Lahillia* cf. *luisa* O. Wilck. sp.
FIG. 3.—Hinge of right valve
FIG. 4.—Portion of hinge of left valve.
FIG. 5.—*Neritopsis?* sp
FIG. 6.—Gastropodum gen. et spec. indet.
FIG. 7.—Ringiculidarum gen. et spec. indet.
FIGS 8*a* and 8*b*.—*Tubulostium* cf. *discoideum* Stol.

In 1910 *Lahillia luisa* was described from the Antarctic Upper Senonian (11), and *L. larseni* Sharm. & Newt. sp. from the Antarctic Tertiary (12). Woods (13) in 1917 described a *Lahillia* from the Upper Senonian of New Zealand under the name *Mactra?* This determination was rectified by me in 1920 (14).

In 1907 v. Ihering (15) wrote, "The genus *Lahillia*, which is well developed in the Upper Cretaceous and Palaeogene faunas of Patagonia and Chile, has not been found in New Zealand," and "*Lahillia* seems not to have reached New Zealand." One sees that his cautious manner of speaking was justifiable.

GASTROPODA.

ARRHOGES Gabb.

Arrhoges haastianus O. Wilck.

1922. *Arrhoges haastianus* O. Wilckens, The Upper Cretaceous Gastropods of New Zealand, *N.Z. Geol. Surv. Pal. Bull. No. 9*, p. 9, pl. 2, figs. 5-7.

An internal cast with strongly weathered surface. The determination would scarcely be possible were the shell not well preserved at the margin of the outer lip, so that the outline of the wing can be seen.

Locality.—Shag Point, loc. 592.

PERISSOPTERA Tate.

Perissoptera waiparaensis (Hector) O. Wilck.

1922. *Perissoptera waiparaensis* (Hector sp.) O. Wilckens, The Upp. Cret. Gastrop. of N.Z., *N.Z. Geol. Surv. Pal. Bull. No. 9*, p. 11, pl. 2, figs. 8, 9.

A sculptured internal cast of 3–4 whorls, reaching down to the beginning of the outer lip.

Locality.—Shag Point, loc. 592.

PROTODOLIUM O. Wilck.

Protodolium speighti (Trechmann sp.).

1917. *Neritopsis speighti* C. T. Trechmann, Cret. Moll. from N.Z., *Geol. Mag.*, n.s., dec. 6, vol. 4, p. 300, pl. 19, figs. 12–15.

1922. *Protodolium speighti* Trechm. sp.: O. Wilckens, Upp. Cret. Gastrop. N.Z., *N.Z. Geol. Surv. Pal. Bull. No. 9*, p. 18, pl. 4, figs. 3–5.

Three sculptured casts. Only to one of these are attached some small remnants of the shell.

The normal internal cast of *Protodolium* possesses smooth whorls. Such sculptured internal casts as occur at the locality 592 (see above, *Lahillia!*) may have been formed in the following manner: The shell was equally dissolved on the whole surface, so that finally the ornamentation was transferred to the cast when the innermost layers of the shell were dissolved.

Locality.—Shag Point, loc. 592. Three specimens.

PLEUROTOMA Lam.

Pleurotoma otagoensis O. Wilck.

1922. *Pleurotoma otagoensis* O. Wilckens, Upper Cret. Gastrop. N.Z., *N.Z. Geol. Surv. Pal. Bull. No. 9*, p. 35, pl. 5, figs. 18, 19.

The specimens are badly preserved sculptured casts, and exhibit nothing that can increase our knowledge of this species.

Locality.—Shag Point, loc. 592. Six specimens.

NERITOPSIS Grateloup.

Neritopsis ? sp. (Plate 54, fig. 5.)

An internal cast of a gasteropod, consisting only of body-whorl and a small portion of penultimate one. Ornamentation is cancellate. There are 6–7 spiral ribs on last whorl, crossed by somewhat retrocurrent axial ribs. At crossing-points ribs form slight tubercles. Aperture and lips not preserved.

Specimen was labelled "*Neritopsis*" and it was stated on the label that this fossil also occurs at locality 83, Waimarama, coast south of Cape Kidnappers, Hawke's Bay (16).

There is a certain similarity between this fossil and *Neritopsis crassa* Stol. (17) from the Utatúr group of Southern India. A definite determination is impossible on account of the poor preservation of the specimen.

Locality.—Shag Point, loc. 592. One specimen.

GASTROPODUM genus et species indet. (Plate 54, fig. 6.)

An internal sculptured cast, consisting of two whorls. The last preserved whorl possesses a sharp median carina. Above this the whorl is declivous, below it is slightly convex. In upper portion of whorl are three rounded spiral ribs, in lower are four of the same kind. It is probably only in consequence of the worse preservation of this portion of the cast that upper ribs are slighter than lower. In figure lower ribs are drawn a little too sharp. In the other whorl median carina is situated at a third of height of whorl above suture.

Genus and species are indeterminable.

Locality.—Shag Point, loc. 592. One specimen.

RINGICULIDARUM genus et species indet. (Plate 54, fig. 7.)

Shell globular, spire inconspicuous. Number of whorls 2½–3. Ornamentation of whorls consists of spiral lirae. There is no punctation of these lirae, but probably this is due to bad preservation of sculpture, for all specimens are only sculptured casts. Body-whorl much inflated and ornamented with more than 30 spiral lines. Aperture large, ovate, angled above, rounded below, and oblique to axis of shell. Outer lip not preserved, but one can see that spiral sculpture ends at an axial groove. It is neither possible to state if outer lip possesses denticulations nor if there are folds on inner lip, so the genus cannot be determined.

The specimens were labelled "*Gilbertia curta* Marsh." This species has been described by P. Marshall from Wangaloa, South Otago (18). It attains only half the height of the specimens here examined. The diversity or the identity cannot be asserted.

Measurements (in millimetres)—

	(*a.*)	(*b.*)	(*c.*)
Height	18·5	18·0	16·5
Diameter	17·5	17·5	15·0

Locality.—Shag Point, loc. 592. Eight sculptured internal casts.

Remarks.—This gasteropod undoubtedly belongs to the family of the Ringiculidae. This is represented in the Pacific Upper Senonian by *Cinulia*, *Eriptycha*, and others. A Ringiculid of perhaps similar dimensions as the fossils here in question is mentioned (19) from loc. 761 (Saurian beds, Middle Waipara).

DENTALIUM L.

Dentalium cf. morganianum O. Wilck.

The material contains a *Dentalium* from locality 22 (Green Island, near Dunedin, greensands). It is a fragment, height of which is 44 mm. and diameter 11·5 mm. at larger and 9·5 mm. at smaller end It lies in an imprint 70·5 mm. long. Shell 2 mm. thick. The fossil agrees well with *Dentalium morganianum* O. Wilck. (20). Shape and growth-lines are the same, only there are some extremely slight axial furrows and rounded ribs. This observation induced me to make a new examination of two specimens of *Dentalium morganianum* still in my hands. I could perceive also in these a very few extremely slight furrows; but there is no real axial sculpture, as I have already pointed out in the description of the species.

Locality.—Green Island, near Dunedin (not an island !). One specimen.

ANNELIDA.

TUBULOSTIUM Stoliczka.

Tubulostium cf. discoideum Stol. (Plate 54, figs. 8*a*, 8*b*.)

The discoid shell is spirally enrolled. One side seems somewhat more concave than the other. Centre of shell not preserved, but only the last two whorls. The last is quadrangular in outer section. On outer periphery it is somewhat concave, and bounded on both sides by a thin sharp keel. On both sides the whorl has a spiral marginal arch near outer keel, bordered interiorly by a spiral furrow, and a second spiral arch. On last third of last whorl are three radial ribs situated at nearly equal distances, the middle one slighter than the others. The first and third are present also on periphery of shell, but it is only the last which continues to its other side.

The shell was labelled "*Discohelix* sp," but undoubtedly this is no *Discohelix*, and no gasteropod at all, but an annelid. This can be stated from the form of the whorls and the irregular surface of the shell.

Dimensions.—Height, 2·5 mm.; diameter, 13 mm.

Locality.—Shag Point, loc. 592. One specimen.

Affinities.—*Tubulostium ornatum* (Hect. MS. sp.) O. Wilck. from the Upper Senonian of New Zealand (21) is quite different, but *Tubulostium discoideum* Stol. (22) from the Utatúr of S. India is related to or even identical with the New Zealand form. The Indian species shows a sudden contraction near the aperture. This is missing in our shell. But it is not impossible that in our specimen this contraction was present and has been broken off.

GENERAL RESULTS.

1. The genus *Lahillia*, a pelecypod genus occurring in the Upper Senonian of Quiriquina (Chile), South Patagonia, and Graham Land (Antarctica), is represented in the Upper Senonian of New Zealand by a species nearly related to or identical with *Lahillia luisa* O. Wilck. sp. In New Zealand *Lahillia* has been collected at the following localities: Amuri Bluff (loc. 13); Middle Waipara (loc. 761); Selwyn River, Malvern Hills (loc. 589); Shag Point (loc. 592).

2. The fauna of Shag Point (loc. 592) is of Upper Senonian age, and comprises the following species:—

Lahillia cf. *luisa* O. Wilck.
Arrhoges haastianus O. Wilck.
Perissoptera waiparaensis (Hoct. sp.) O. Wilck.
Protodolium speighti Trechm. sp.
Pleurotoma otagoensis O. Wilck.
Neritopsis sp.
Gastrop. gen. et sp. indet.
Ringiculidarum gen. et sp. indet.
Tubulostium cf. *discoideum* Stol.

3. The locality Shag Point 320 is also of Upper Senonian age. This was left in uncertainty before (23).

4. *Dentalium* cf. *morganianum* O. Wilck. indicates an Upper Senonian age of the locality 22 (Green Island, near Dunedin).

5. The material examined has yielded three species, which are new for the Upper Senonian of New Zealand: *Neritopsis ?;* a gasteropod, genus and species indeterminable; and *Tubulostium* cf. *discoideum* Stol. Perhaps the described ringiculid gasteropod is also a new species. It is noteworthy that *Conchothyra parasitica*, which is common at all localities of Upper Senonian age in the South Island of New Zealand, does not occur at Shag Point.

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20. —— The Upper Cret. Gastr. of N.Z., *ibid.*, p. 24, pl. 5, figs. 8, 9.
21. —— The Upper Cret. Gastr. of N.Z., *ibid.*, p. 25, pl. 5, figs. 10–12.
22. F. Stoliczka, Cret. Fauna of S. India, *Palaeontologica Indica*, vol. 2, Gastropoda, p. 240, pl. 18, figs. 20–25 (especially fig. 21).
23. O. Wilckens, The Upper Gastr. of N.Z., *N.Z. Geol. Surv. Pal. Bull. No. 9*, p. 36.

The Tertiary and Recent Naticidae and Naricidae of New Zealand.

By J. MARWICK, M.A., D.Sc.

[*Read, by permission of the Director of the N.Z. Geological Survey, before the Wellington Philosophical Society, 10th October, 1923; received by Editor, 22nd December, 1923; published separately, 28th August, 1924.*]

Plates 55–60.

I. Family NATICIDAE.

A SATISFACTORY classification of the Naticidae is, for the following reasons, difficult to carry out: (1) The importance that has been attributed by most authors to the calcareous or horny nature of the operculum; (2) the use of the funicle in classification; (3) the absence of sculpture; (4) the great variability in shape within many of the species.

1. Cossmann (1919, p. 385) criticizes the system of generic division according to the nature of the operculum, and cites *Natica dillwynni* Payr. as the possessor of an operculum partly horny and partly calcareous.

2. The umbilical funicle is by no means a constant, and when coalescent with the parietal callus loses its individuality. In some cases *e.g.*, *N. maoria* —it becomes quite obsolete.

3. The only sculpture is of simple spiral grooves and cords. On *Sinum* and its allies this is well developed, but is of a very uniform nature throughout. In the other groups weak spirals are often present, particularly in some of the large *Uber* spp., but here they do not have even specific significance.

4. Dall (1892, p. 362) says, "The males, as usual, are apt to be smaller, and, not having to carry the enormous egg-sac of the females, have the 'shoulder' of the shell, or that part of the whorl just in front of the suture, less inflated, giving the whole shell a more evenly conical and less scalar spire. These differences are more marked in the group having an elevated operculum, but are perceptible in the others, especially [illegible] spire. Apart from sexual differences, there is a certain variability about the coil of the shell, some specimens having a decidedly wider umbilicus than others of the same species; and the grooves and spiral ribs of the interior of the umbilicus vary within certain limits between individuals, and also have a certain range of fluctuation in the same individual at different times."

The system of nomenclature followed below is based mainly on Dall's two papers (1892, 1909), but a departure is made in giving *Amauropsella* generic rank. It has also been found necessary to set up two new genera and two new subgenera. *Sulconacca* is proposed for some of the shells classed under *Ampullina* (*Megatylotus*) by Suter and under *Lunatia* by Hutton; *Globisinum* for the globose shells with spiral sculpture classed sometimes as *Sinum* and sometimes as *Ampullina*; *Magnatica* and *Carinacca* for Naticoid groups, the latter of which was placed under *Lunatia* by Hutton and *Ampullina* by Suter, the former under *Polinices* by Suter.

The table of generic and subgeneric ranges reveals no important additions to the New Zealand fauna since Bortonian times. (The one exception, *Eunaticina cincta*, as stated below, is based on a single specimen of doubtful authenticity.) At first sight this might seem to point to an isolation of the area during that time, preventing the arrival of new forms. Judging from our limited knowledge, however, the generic constitution of neighbouring areas does not seem to have been very different from our own. Thus new arrivals might not be noticed.

The family seems to have had its maximum development as regards differentiation early in the Tertiary, so that few new generic divisions have been evolved since the Oligocene. A noticeable feature shown by Table 1 is the appearance of five new genera or subgenera after the Wangaloan, perhaps indicating an ingression of a northern fauna, for *Natica* s. str. appears to have been absent from the early Tertiary and Cretaceous of Antarctica.

The time divisions used in Tables 1 and 2 below are approximations only, and the terms are used in a very wide sense; also, some changes have been made in Thomson's classification (1916, p. 28 *et seq.*). The Ngaparan has been omitted, since it is based on non-marine sediments. The Bortonian (Park, 1916, p. 34) has been separated from the Waiarekan, and includes, besides the type locality, the Waihao greensands and "Island sandstone," the Kakahu greensands, and the Hampden beds. The stage as thus constituted still represents a long period of time, and should be further divided. The Waiarekan has been reduced to embrace only the tuffs below the Ototaran stone, and with it have been placed, tentatively, the Chatton Creek beds. Of the Ototaran molluscan fauna little is known, for it has not yet been demonstrated what littoral beds of fossiliferous sandstones form the lateral equivalent of the limestone. The Hutchinsonian has been omitted because only its Brachiopod fauna is, as yet, accurately known. The Pakaurangi Point, Clifden, and Otiake beds have been included in the Awamoan largely because the faunal resemblances are with that stage rather than with the Waiarekan, and because of the uncertainty as to the equivalents of the Ototaran and Hutchinsonian. According to information from Mr. H. J. Finlay, a considerable thickness of the fossilferous Clifden beds corresponds to these stages.

ACKNOWLEDGMENTS.

I am indebted to Mr. R. S. Allan and Mr. H. J. Finlay for their generous loan of material and for permission to incorporate into this paper, for the sake of completeness, species that they had already separated out as new; also to the late Mr. R. Murdoch, Miss M. K. Mestayer, Dr. P. Marshall, Mr. W. R. B. Oliver, Professor R. Speight, and Dr. J. A. Thomson for their kindness in lending valuable specimens for examination.

TABLE 1.—APPROXIMATE TIME RANGES OF GENERA AND SUBGENERA.

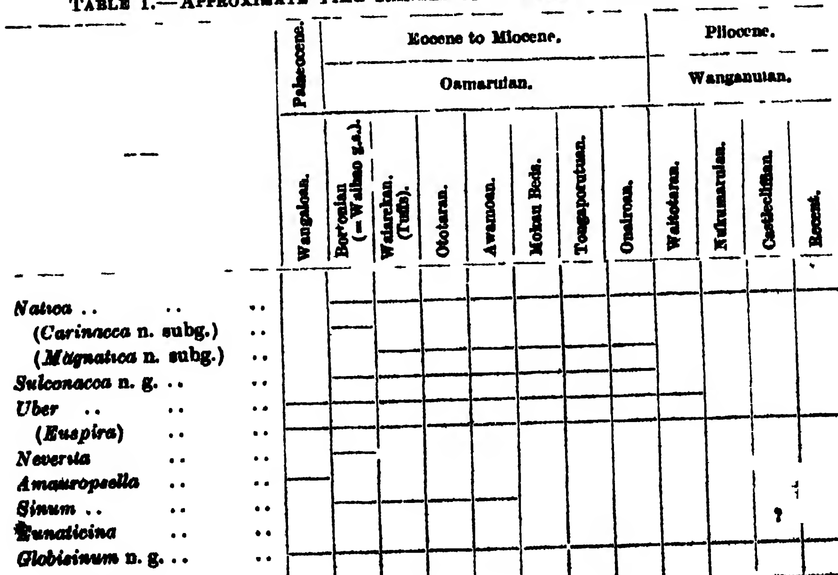


TABLE 2.—APPROXIMATE SPECIFIC TIME RANGES.

	Wangaloan.	Bortonian (= Waihao g.s.).	Waiarekan (Tuffs).	Ototaran.	Awamoan.	Mokau Beds.	Tongaporutuan.	Onairoan.	Waitotaran.	Nukumaruian.	Castlecliffian.	Recent.
Natica praeconsors ..		—										
—— *consortis*					—							
—— *sublata*					—							
—— *notocenica*		?			—							
—— *bacca*		—										
—— *harrisensis*					—							
—— *denticulifera* ..								—	—	—	—	—
—— *haweraensis* ..									—			
—— *planisuturalis* .										—		
—— *maoria* .. .										—	—	—
—— *maesta*								—				
—— *zelandica*											—	—
—— *inexpectata* ..					—							
—— *haasti*		—										
—— *waihaoensis* ..		—										
—— *allani*		—										
—— *sutherlandi* ..			?									
—— *approximata* ..		—	—									
—— *suteri*			—	—	—							
—— *nuda*							—	—				
Sulconacca suturalis .		—										
—— *prisca*		—										
—— *compressa*					—							
—— *vaughani*					—	—	—	—				
Uber finlayi	—											
—— *senisculus*	—											
—— *kaawaensis* ..									—			
—— *esdailei*			—									
—— *incertus*					—							
—— *modestus*					—							
—— *obstructus*				—	—	—	—	?				
—— *huttoni*				—	—	—	—					
—— *sagenus*					—							
—— *mucronatus* ..							—					
—— *intracrassus* ..							?					
—— *lobatus*					—							
—— *unisulcatus* ..							—	—				
—— *waipaensis* ..			—	—								
—— *chattonensis* ..			?									
—— *propeovatus* ..					—	—	—	—				
—— *waipipiensis* ..									—			
—— *pateaensis*									—			
—— *ovuloides*									—			
—— *fyfei*	—	?										
—— *firmus*	—	—										

TABLE 3.—APPROXIMATE SPECIFIC TIME RANGES—*continued.*

—	Wangaloan.	Bortonian (= Waihao g.s.).	Waiarekan (Tuffs).	Ototaran.	Awamoan.	Mokau Beds.	Tongaporutuan.	Onairoan.	Waitotaran.	Nukumaruan.	Castlecliffian.	Recent.
Uber lateapertus ..	—											
—— *pukeuriensis* ..					—							
—— *pseudovitreus* ..					—							
—— *vitreus*												—
—— *barrierensis* ..												—
—— *pontis*		—										
Amauropsella major ..	—											
—— *teres*	—											
Sinum fornicatum ..		—										
—— *infirmum*					—							
—— *cinctum*											?	
Globisinum spirale ..	—											
—— *elegans*		—										
—— *miocaenicum* ..					—							
—— *drewi*										—	—	
—— *undulatum*										—	—	—
—— *venustum*												—

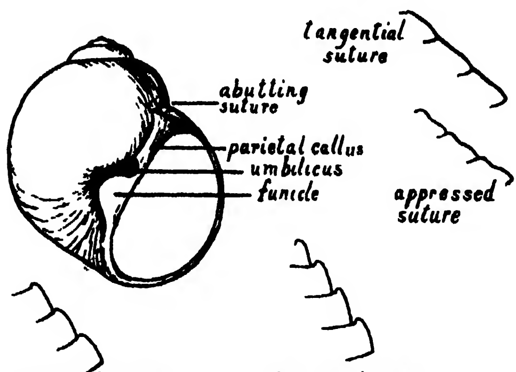


DIAGRAM TO ILLUSTRATE TERMS USED.

ROUGH KEY TO GENERA AND SUBGENERA.

1. *Natica:* Globose; sutures generally abutting, but sometimes tangential; parietal callus thin, separated from a prominent funicle in the umbilicus; operculum shelly.
   (*a.*) (*Carinacca*): Ovate; sutures tangential; umbilicus widely open, bounded by a limb without an accompanying sulcus; funicle rudimentary; parietal callus short but fairly thick.
   (*b.*) (*Magnatica*): Large, globose; sutures tangential; umbilicus open, with a weak ridge on apertural wall, also a weak circum-umbilical limb.
2. *Sulconacca:* Small, globose; sutures channelled; umbilicus open, bounded by a low ridge with a well-marked sulcus outside it; no funicle; parietal callus only a thin glaze.

4. *Uber:* Ovate; sutures generally tangential; umbilicus open or closed by the parietal callus, which is thick and coalescing with the funicle; operculum horny.
   (*a.*) (*Euspira*): Globose-ovate; sutures abutting, sometimes appressed; apertural callus moderate; no funicle; operculum horny.
   (*b.*) (*Neverita*): Ovate; sutures tangential, appressed; apertural callus thick, coalescing with a huge funicle, which fills the umbilicus; aperture greatly inclined.
4. *Sinum:* Auriform, extremely flattened, with strong spiral sculpture; aperture distended; columella without callus, concave.
   (*a.*) (*Eunaticina*): Oval; body-whorl compressed, strong spiral sculpture; aperture distended; columella without callus, slightly sinuous.
5. *Globisinum:* Globose; strong spiral sculpture; inner apertural margin without callus and shaped as a shallow reversed S.
6. *Amauropsella:* Shell ovate; spire raised; aperture slightly effuse below; umbilicus with a sharp spiral ridge descending to the anterior end of the inner lip; parietal callus thin.

1. Genus NATICA Scopoli, 1777.

Shell globose, solid, smooth, suture well marked and generally abutting, aperture semilunar, outer lip straight, often retracted to suture, inclined 20°–30° from vertical, inner margin with moderate callus on parietal wall generally not invading umbilicus which is open and contains a funicle spiralling up apertural wall.

Type: *N. vitellus* Linné.

KEY TO SPECIES.

zelandica. fairly large, globose; sutures abutting; funicle large, close to anterior and outer umbilical walls, separated from the parietal callus by a notch about half as wide as the funicle.

inexpectata. fairly large, globose; sutures abutting strongly; funicle moderate.

notocenica: small, ovate; sutures tangential; funicle comparatively larger than that of *zelandica*.

bacca: very small, broadly ovate; sutures tangential; funicle rather narrow but long.

planisuturalis: moderate size, broadly ovate; sutures tangential; funicle moderate, about half its own width from the umbilical walls.

haweraensis: moderate size, broadly ovate; sutures tangential; funicle narrow, separated its own width from umbilical walls.

consortis. small, globose; spire rather low; sutures abutting; funicle very small, anteriorly placed.

sublata: small, ovate; spire high, gradate; sutures abutting with a flat space below; funicle very small, anteriorly placed.

praeconsors: small, globose; spire low; sutures abutting; umbilicus with two weak funicle ridges.

harrisensis: small, flattened; sutures abutting; umbilicus with a ridge very far forward; two denticles on the parietal callus.

maesta: small, spire low, body subcylindrical; suture impressed; umbilicus very narrow.

maoria: small, globose; sutures abutting; umbilicus variable, sometimes widely open and without trace of a funicle, sometimes restricted and almost closed by a narrow funicle coalescing with the parietal callus.

denticulifera: small, ovato-globose; spire high; sutures abutting; umbilicus without a funicle; parietal callus with one or two denticles.

Natica zelandica Quoy and Gaimard, 1832. (Plate 55, figs. 8, 12.)

For synonymy see Suter's *Manual* (1913, p. 289).

Localities.—Recent (type); Castlecliff, Wanganui; Kai Iwi.

This species has been recorded from many Tertiary horizons, from the Hampden beds upwards; but the identifications do not bear critical examination. As here restricted, *N. zelandica* has a very short range—*i.e.*, Castlecliffian to Recent.

Natica notocenica Finlay. (Plate 55, fig. 4.)

1924. *Natica notocenica* Finlay, *Trans. N.Z. Inst.*, vol. 55, p. 450, pl. 49, figs. 2*a*, 2*b*, 2*c*, 2*d*.

Localities.—Awamoa (type); Pukeuri; Rifle Butts; Ardgowan; Pareora; uppermost Mount Brown beds, Weka Pass, large specimen [= *N. australis* (in part) of Suter, 1921, p. 43]; ? Waikaia (umbilicus is concealed by matrix); ? McCullough's Bridge, Waihao.

One good specimen from the last locality has outer lip strongly retracted to suture and funicle smaller and more separated from umbilical walls. Two smaller imperfect specimens are not so distinct from *notocenica*, consequently more specimens are needed before a separation would be justified.

Natica inexpectata Finlay. (Plate 55, fig. 13.)

1924. *Natica inexpectata* Finlay, *Trans. N.Z. Inst.*, vol. 55, p. 452.

Type in the collection of Mr. H. J. Finlay.

Height, 16 mm.; diameter, 15 mm.

Locality.—7A, Clifden, Southland.

Distinguished from *N. zelandica* by its different shape, more convex and wider whorls, and smaller umbilical funicle. *N. consortis* and *N. sublata* are only about half the size, and have much smaller funicles.

Natica bacca n. sp. (Plate 55, fig. 14.)

Shell small, oval; spire low, suture tangential; aperture large, semilunar; outer lip gently retracted to suture for considerable distance; inner lip with thin callus on parietal wall and somewhat narrow but large funicle which about half fills umbilicus; notch separating funicle from parietal callus very shallow.

Type in collection of New Zealand Geological Survey. Kindly presented by Dr. P. Marshall.

Height, 5 mm.; length, 5 mm.

Locality.—Hampden.

This species is probably the *N. zelandica* of former lists. The very shallow notch between the parietal callus and the funicle, and also the narrowness of the latter, distinguish the species from *N. notocenica*, which it resembles in shape.

Natica planisuturalis n. sp. (Plate 55, figs. 10, 11.)

Shell small, broadly ovate; spire moderately raised, less than half the height of aperture; whorls 5, flattened above; suture tangential; outer lip slightly concave, inclined at about 30° from the vertical, slightly retracted to suture; umbilicus wide with an almost central funicle about half its own width from umbilical walls all round; parietal callus thin with deep narrow notch separating it from funicle.

Holotype in collection of New Zealand Geological Survey.

Height, 11 mm.; diameter, 11 mm.

Localities.—1089, blue clays and sands, Okauawa Creek, south side Ngaruroro River (type); 1063, shell-bed, Okawa Creek, north side Ngaruroro River; 1096, clays below limestone, Petane.

Natica haweraensis n. sp. (Plate 55, figs. 6, 7.)

Shell small, broadly ovate; spire low; whorls somewhat flattened, suture tangential; outer lip slightly concave, inclined at about 40° from vertical, slightly retracted to suture; umbilicus very wide with large funicle which is its own width distant from umbilical walls all round; parietal callus thin, not invading umbilicus, and so separated from funicle by deep and wide notch.

Holotype in collection of New Zealand Geological Survey.

Height, 10 mm.; diameter, 10 mm.

Localities.—1173, beach at mouth of Waihi Stream, Hawera; 1101, Waipipi Beach, north of Wairoa Stream, Waverley (= *N. zelandica* of Marshall and Murdoch, 1920, p. 125); 126, Awatere Valley (= *P. ovatus?* of Suter, 1921, p. 30) (poor specimen; may be *N. planisuturalis*).

An imperfect specimen from Waipipi Beach is 20 mm. high.

Natica consortis Finlay. (Plate 55, fig. 2.)

1924. *Natica consortis* Finlay, *Trans. N.Z. Inst.*, vol. 55, p. 451, pl. 49, figs. 1*a*, 1*b*, 1c.

Localities.—Pukeuri (type); Target Gully, Oamaru; Parson's Creek, Oamaru; Ardgowan; Rifle Butts; Pakaurangi Point.

Natica sublata n. sp. (Plate 55, fig. 3.)

Shell small, ovate; spire raised, gradate; whorls 5 6, convex on spire, flattened immediately below suture, which is well marked and abutting; growth-lines very strongly marked on subsutural space, surface otherwise smooth; aperture ovate; outer lip straight or slightly concave, retracted to suture, inclined about 25° from vertical; inner lip thin; umbilicus small, with small anteriorly placed funicle separated from parietal glaze by notch of equal width.

Holotype in collection of New Zealand Geological Survey.

Height, 8 mm.; diameter, 7 mm.

Locality.—165, White Rock River, Pareora.

This species is closely related to *N. consortis*, having the same umbilical development with a characteristically small funicle; it is easily distinguished by its narrower diameter, raised spire, and flattened subsutural space with strong growth-lines. (= *N. zelandica* and *N. australis* of Suter, 1921, p. 59.)

Natica praeconsors Finlay. (Plate 55, fig. 1.)

1924. *Natica praeconsors* Finlay, *Trans. N.Z. Inst.*, vol. 55, p. 451.

The funicle is very small, and there is another smaller umbilical ridge placed well forward, like the ridge in *Amauropsella*. Perhaps the shell is worth sectional distinction from *Natica* s. str., but only one specimen was seen by the writer.

Locality.—McCullough's Bridge, Waihao.

Natica harrisensis n. sp. (Plate 55, fig. 5.)

Shell small, oval; spire almost flat; whorls 4, convex on spire, body-whorl wide increasing rapidly in size; suture well marked, abutting, with indistinct flattening of whorl below; aperture semilunar; outer lip

retracted to suture above but otherwise straight, inclined at about 20° from vertical; umbilicus small but penetrating, hardly encroached on by apertural callus, which bears two denticles on lower part; an extremely small and anteriorly placed funicle, amounting only to a ridge, descends from within umbilicus to abut on inner lip just before it curves round to base.

Holotype in collection of New Zealand Geological Survey.

Height, 6 mm.; length, 6 mm.

Locality.—Mount Harris, South Canterbury. (= *P. amphialus* of Suter, 1921, p. 64.)

A fairly large shell of a similar nature occurs in bed 6B at Clifden, Southland, but the available specimens were not complete enough to show whether they were adults of the Mount Harris shell or a different species.

Natica maoria Finlay. (Plate 55, figs. 16, 18.)

1878. *Lunatia australis* Hutton, *Journ. d. Conch.*, vol. 26, p. 23.
1893. *Natica australis* Hutton, *Macleay Mem. Vol.*, p. 54, pl. 7, fig. 38 (not of d'Orbigny).
1924. *Natica maoria* Finlay, *Proc. Malac. Soc.*, vol. 16, p. 101.

Lectotype in Otago Museum.

Height, 6 mm.; diameter, 6 mm.

Localities.—Recent (type from Auckland); Castlecliff; Kai Iwi; 1063, Okawa Creek, Ngaruroro River; 1096, Esk Bridge, Petane; 1040, Twaite's Cutting, five miles south of Martinborough.

Each of Hutton's three syntypes has a fairly open umbilicus and obsolete funicle. Other specimens from Auckland in Suter collection and in Dominion Museum have a very narrow umbilicus almost filled by the rather narrow funicle. It may be that we are dealing with two species, for the shell in the Petane beds commonly classed as *N. australis* has a very wide umbilicus and a thinner inner lip than the typical specimens, and no examples with a narrow opening were seen. At Castlecliff and Kai Iwi both forms are present, so it seems advisable for the present to recognize only one species.

In the widely umbilicated specimens the funicle is absent; sometimes, but not always, there is a slight furrow to mark its lower extremity. Such shells as the Petane ones, if considered on their own merits, would be classed as *Euspira*, but they are certainly closely related to if not specifically identical with *N. maoria*, which has a shelly operculum.

Natica denticulifera n. sp. (Plate 55, fig. 9.)

Shell small, ovate; spire raised, over half height of aperture; whorls 5, convex, often slightly depressed below suture; protoconch smooth, nucleus moderate; whorls polished, with irregular microscopic spirals; growth-lines well marked, stronger near suture, which is abutting; aperture semilunar; outer lip very slightly sinused above and scarcely retracted to suture, inclined 25° from vertical, inner margin straight with light parietal callus, lower border of which half-covers umbilicus; lower outside corner of callus marks apex of a triangular shallow depression with a small denticle on each side; umbilical funicle is absent unless lower part of apertural callus represents it.

Holotype in collection of New Zealand Geological Survey.

Height, 9 mm.; diameter, 8 mm.

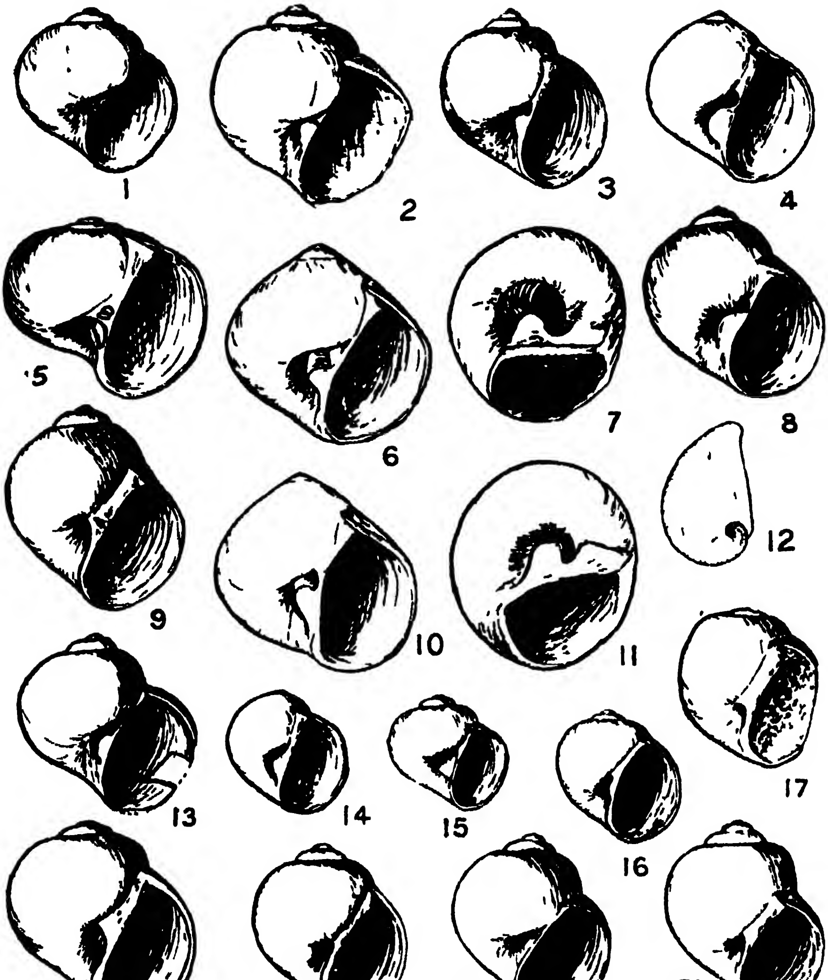
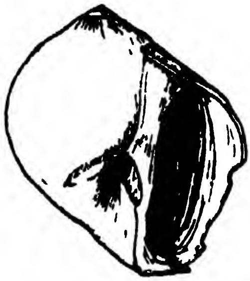


FIG. 1.—*Natica praeconsors* Finlay: holotype. × 3.
FIG. 2.—*Natica consortis* Finlay: holotype. × 3.
FIG. 3.—*Natica sublata* n. sp.: holotype. × 3.
FIG. 4.—*Natica notocenica* Finlay: holotype. × 3.
FIG. 5.—*Natica harrisensis* n. sp.: holotype. × 4.
FIGS. 6, 7.—*Natica hawerаensis* n. sp.: holotype. × 2½
FIGS. 8, 12.—*Natica zelandica* Q. & G., Kai Iwi. × 1.
FIG. 9.—*Natica denticulifera* n. sp.: holotype. × 3.
FIGS. 10, 11.—*Natica planisuturalis* n. sp.: holotype. × 2½.
FIG. 13.—*Natica inexpectata* Finlay: holotype. × 1
FIG. 14.—*Natica bacca* n. sp.: holotype × 3.
FIG. 15.—*Polinices (Euspira) barrierensis* n. sp.: holotype. × 3.
FIG. 16.—*Natica maoria* Finlay, Auckland, Recent. × 3.
FIG. 17.—*Natica maesta* n. sp.: holotype. × 3.
FIG. 18.—*Natica maoria* Finlay: lectotype. × 4.
FIG. 19.—*Uber (Euspira) vitreus* (Hutton): lectotype. × 3.
FIG. 20.—*Uber (Euspira) pukeuriensis* n. sp.: holotype. × 4.
FIG. 21.—*Uber (Euspira) pseudovitreus* (Finlay): holotype. × 3.

Face p. 552.]



1

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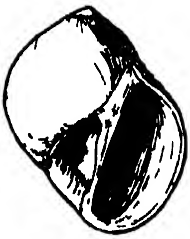

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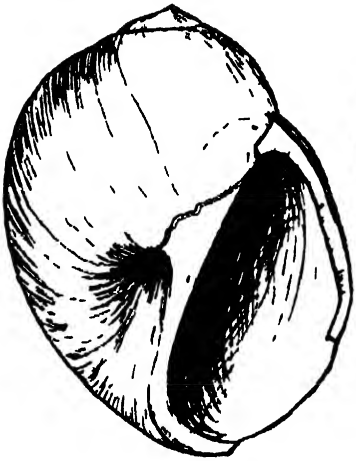

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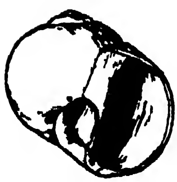

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FIG. 1.—*Natica (Magnatica) sutherlandi* n. sp.: holotype. × 1.
FIG. 2.—Operculum of *N. suteri*, Trig. Z, Otekaike. × 1.
FIG. 3.—*Natica (Magnatica) approximata* (Suter): topotype. × 1.
FIG. 4.—*Natica (Carinacca) allani* n. sp.: holotype. × 1½.
FIG. 5.—*Natica (Magnatica) suteri* n. mut., Kekenodon beds. × 1.
FIG. 6.—*Natica (Magnatica) suteri* n. mut., Trig. Z., Otekaike. × 1.
FIG. 7.—*Natica (Carinacca) waihaoensis* (Suter): topotype. × 1½.
FIG. 8.—*Natica (Carinacca) haasti* n. sp.: holotype. × 3.
FIG. 9.—*Natica (Magnatica) nuda* n. sp.: holotype. × 2.

Localities.—Recent specimens in Dominion Museum, locality unknown; Castlecliff, Wanganui; 1163, Kai Iwi, Wanganui (type); 1096, clay below limestone, Petane; 1145, mouth of Onairo Stream, Waitara Survey District; 1146, mouth of Waiau Stream, Waitara Survey District.

It is possible that this shell is a *Uber* (*Euspira*), for it closely resembles *P. vitreus.* It is just as like the openly umbilicated forms of *N. maoria*, however, so is classed here as a *Natica.*

Natica maesta n. sp. (Plate 55, fig. 17.)

Shell small, suboval; spire depressed; whorls convex, body-whorl subcylindrical; suture deeply impressed; aperture semilunar; outer lip slightly concave in middle, antecurrent to suture, inclined about 20° from vertical; inner lip with moderate parietal pad of callus coalescing with so as to mask funicle; umbilicus very narrow, almost closed.

Type in collection of New Zealand Geological Survey.

Height, 7 mm.; diameter, 7 mm.

Localities. -1129, Whitecliffs, Taranaki (type); Tukituki, Waiapu, East Cape district.

This species is somewhat like some Recent forms of *N. maoria* with an almost closed umbilicus, but it differs from them in its deeply impressed suture. The Waiapu specimen is more effuse at anterior corner of aperture, and more specimens might justify their separation as a distinct species.

a. Subgenus CARINACCA n. subg.

Shell of moderate size, ovate, smooth, widely umbilicated; spire low; suture sometimes slightly impressed but generally tangential; aperture semilunar; outer lip practically straight but strongly retracted to suture, inclined 25° to 30° from vertical; inner margin straight with short, fairly thick parietal callus; umbilicus with an obsolete funicle on its long apertural margin (sometimes absent altogether), and bounded by broad strong ridge formed by a prominent thickening of apertural margin at anterior corner.

Type: *Ampullina waihaoensis* Suter.

Suter classed the type under *Ampullina* because of the strong basal limb, but it differs from that genus in its ovate shape, tangential suture, rudimentary umbilical funicle, and also in the disposition of the basal limb. In *Ampullina* this is a step, but in *A. waihaoensis* it is a well-defined ridge. There is considerable similarity to *Natica burdigalensis* Mayer and related species (Aquitainian), although none of them has such a well-developed basal limb. *Natica macrotrema* Ad. & Reeve from the living fauna of Borneo (Tryon, 1886, pl. 22, fig. 27) also appears to be related.

b. Subgenus MAGNATICA n. subg.

Shell large, globose, smooth; spire low, often almost flat, suture tangential; aperture similunar; outer lip with a sharp edge, slightly sinuous and strongly retracted to suture, inclined about 25° from vertical; inner margin straight with moderate parietal callus; umbilicus always open, with a weak funicular ridge or step inclined to become obsolete, and bounded by a broad but low limb which also tends to become obsolete.

Type: *Polinices planispirus* Suter (= *Natica suteri* Marwick).

Key to Species.

Carinacca.

(*a.*) Suture impressed, not tangential.
haasti : very small ; no funicle, huge basal limb.
(*b.*) Suture tangential.
waihaoensis : moderate size, broadly ovate ; large basal limb, very wide umbilicus, slight funicle coalescing with parietal callus.
allani : moderate size, ovate ; large basal limb, large umbilicus, slight coalescing funicle.

Magnatica.

sutherlandi : fairly large, broadly ovate ; weak basal limb, moderate umbilicus, funicular ridge separated from callus.
approximata : fairly large ; obsolete basal limb, rather small but open umbilicus, funicular ridge present but weak, a groove from umbilicus across callus.
suteri : large, broadly ovate to oval ; obsolete basal limb ; umbilicus variable, never very large ; traces of funicular ridge.
nuda : small, broadly ovate ; obsolete basal limb ; umbilicus fairly large, funicular ridge obsolete.

Natica (Carinacca) waihaoensis (Suter). (Plate 56, fig. 7.)

1917. *Ampullina waihaoensis* Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 11, pl. 11, fig. 10.

As Suter's type specimen was imperfect, he did not note the slight thickening of the umbilical wall on the apertural side. In some specimens this feature is quite well marked, and evidently corresponds to the funicle of *Natica* s. str.

Locality.—Greensand, McCullough's Bridge, Waihao.

Natica (Carinacca) haasti n. sp. (Plate 56, fig. 8.)

Shell small, broadly oval ; spire low, about one-third height of aperture ; whorls 4 ; protoconch with moderate nucleus ; surface with fine growth-lines, suture impressed not channelled ; aperture broadly semilunar ; outer lip straight, slightly retracted to suture, inclined about 30° from vertical ; inner lip with thin parietal callus not invading umbilicus, which is relatively large and bounded by very strong broad limb which forms prominent thickening at anterior corner of aperture.

Type in collection of Mr. R. S. Allan.

Height, 7 mm. ; diameter, 8 mm.

Localities.—McCullough's Bridge, Waihao ; Hampden (one specimen is 13 mm. in height = *Ampullina suturalis* of Marshall, 1923, p. 117).

Natica (Carinacca) allani n. sp. (Plate 56, fig. 4.)

Shell small, ovate ; spire less than one-third height of aperture, with almost straight outlines ; protoconch of three and a half smooth whorls with minute nucleus, sutures slightly impressed but almost tangential, whorls depressed somewhat below it ; aperture semilunar ; outer lip straight, strongly retracted to suture, inclined about 25° from vertical ; inner lip with short, fairly thick callus on parietal wall, coalescing below with slight funicular thickening ; umbilicus widely open, bounded by high wide arm caused by a prominent thickening of anterior corner of apertural margin.

Type in collection of Mr. R. S. Allan.

Height, 19 mm. ; diameter, 16·5 mm.

Localities.—Greensand, Waihao Downs; 164, Greensand above coal-beds, Kakahu, South Canterbury (= *P. ovatus* and *P. huttoni* of Suter, 1921, p. 53); 176, sandstone above coal-beds, Black Point, Waitaki Valley (= *P. ovatus* of Suter. 1921, p. 72); Hampden (= *Ampullina waihaoensis* of Marshall, 1923, p. 117).

Distinguished from *N. waihaoensis* by narrower shape and more restricted umbilicus.

Natica (Magnatica) sutherlandi n. sp. (Plate 56, fig. 1.)

Shell large, broadly ovate; spire low and with almost straight outlines; whorls 6, slightly depressed in front of suture; protoconch nucleus very small; suture tangential; surface with sinuous growth-lines, stronger above; aperture semilunar; outer lip concave, strongly retracted to suture, inclined about 30° from vertical; inner lip with moderate callus on parietal wall; umbilicus well open, with well-marked funicular ridge and circum-umbilical limb which forms a prominent angle where it meets anterior margin.

Type in collection of Mr. R. A. Sutherland, Wanganui.

Height, 32 mm.; diameter, 32 mm.

Localities.—Chatton Creek, Gore; ? Trig. M, Totara, small specimen (= *P. amphialus* of Suter, 1921, p. 88).

Natica (Magnatica) approximata (Suter). (Plate 56, fig. 3.)

1917. *Turbo (Marmorostoma) approximatus* Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 6, pl. 2, fig. 5.

The type of *Turbo approximatus* is in an extremely poor state of preservation, squeezed out of shape, and with the front half of the shell missing. It should never have been described. Fortunately, in the same collection is a fairly well-preserved shell, squeezed in the same manner and undoubtedly of the same species. This was identified by Suter as *Polinices huttoni* (1921, p. 68). Close relationship exists with *P. planispirus* Suter (now *N. suteri*), but there is always a groove running from the umbilicus across the callus towards aperture and slightly upwards. There is a low funicular ridge in the umbilicus, which is moderately open, and bounded by an obsolete arm not definitely marked off.

Localities.—486, Wharekuri greensand; Kakanui tuffs (H. J. Finlay).

Natica (Magnatica) suteri nom. mut. (Plate 56, figs. 2, 5, 6.)

1917. *Polinices planispirus* Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 10, pl. 3, figs. 1, 2 (not *N. planispira* of Phillips).

Suter generally identified this species as *Polinices huttoni*, especially the specimens from the Waitaki Valley. It will be shown below that *P. huttoni* = *P. gibbosus*, and is not an openly umbilicated shell like this one. In the original description no mention is made of the low funicular ridge in the umbilicus, but Suter's fig. 1 shows it. The specimens from locality 476, at least, are of variable shape; some have an almost flat summit like the type, others have a fairly high spire (see Plate 56, fig. 5). The size of the umbilical opening and the strength of the funicular and circum-umbilical ridges also are inconstant, so that more specific divisions may be required. At Trig. Z, Otekaike, where these shells are common, occur many large calcareous Naticid opercula which must belong to them, for there is no other shell to which they can be attributed. According to our present system

of classification, the species cannot, therefore, be placed under *Polinices* (= *Uber*), which has a horny operculum. The change to *Natica* necessitates an alteration of the specific name, for there is a prior *Natica planispira* Phillips (*Illust. Geol. Yorkshire*. pt. 2, 1836, p. 224, pl. 14, fig. 30).

Localities.—Blue Cliffs, South Canterbury, immediately above limestone (type); 476, "Kekenodon beds," Wharekuri; 526, Okoko; 477, "Otekaike limestone," Station Peak, Waitaki Valley; 733, Orbitolite limestone, Hokianga South Head; Trig. Z, Otiake beds above Otekaike limestone (G. H. Uttley); 1160, Awamoa Creek (J. Marwick).

Natica (Magnatica) nuda n. sp. (Plate 56, fig. 9.)

Shell small, strong; spire low with almost straight outlines, one-quarter of height of aperture; whorls 4, convex, flattened or even concave below tangential suture, which is descending on body-whorl; surface with fine growth-lines only; aperture semilunar; outer lip straight, strongly retracted above to suture, inclined 32° from vertical; inner lip calloused on parietal wall, and thickened again below where basal limb abuts; umbilicus wide, bounded by an obsolete rounded ridge.

Holotype in collection of New Zealand Geological Survey.

Length, 13 mm.; diameter, 13 mm.

Localities.—1134, coast quarter-mile north of Papatiki Stream, North Taranaki; 1117, coast 3 chains north of Maungapuketea Steam, Mimi Survey District, North Taranaki (L. I. Grange).

2. Genus Sulconacca n. gen.

Shell moderate to small in size, smooth, umbilicated; spire low, gradate; protoconch with minute nucleus; suture deeply channelled; aperture semilunar; outer lip straight or slightly concave, sometimes gently retacted to suture, inclined 20° from vertical; inner margin straight, with thin enamel on parietal wall; umbilicus always open, bounded by low ridge outside which is a broad sulcus caused by an angular thickening of anterior apertural margin, on exterior of which is a notch.

Type: *Sulconacca vaughani* Marwick.

Suter classed all the shells embraced by this genus as *Ampullina* (*Megatylotus*) *suturalis* (Hutton). *Megatylotus* is founded on a huge shell, *N. crassatina* Lamk., which has a wide basal callosity covering the umbilicus, and with a folded outer margin: there is an umbilical chink in the young but there is no basal sulcus.

The sulcus also distinguishes *Sulconacca* from *Ampullina*, in which the basal limb has the nature of a collar or a step. The ridge bounding the inside of the sulcus of *Sulconacca* is not unlike that in the Eocene *Amauropsina* Chelot, which Cossmann (1919, p. 392) considers a subgenus of *Natica*. In Chelot's subgenus, too, the suture is canaliculate.

Further support for the closer relationship to *Natica* than to *Ampullina* is presented by the groups of shells here classed under the new subgenera *Carinacca* and *Magnatica*. The small *N. haasti*, with its impressed suture and no funicle, could easily be mistaken for a *Sulconacca*, but a careful examination shows that it has the same basal limb as *A. waihaoensis*, which has a weak funicle, and is related through *N. sutherlandi* to *N. approximata* and *N. suteri*, a shelly-operculate species.

KEY TO SPECIES.

suturalis: globose; sutural channel about 0·75 mm. wide; outer lip retracted to suture.
prisca: slightly compressed; channel about 1 mm. wide; outer lip concave, noticeably retracted to suture.
compressa: compressed; channel about 0·75 mm. wide; outer lip slightly retracted to suture.
vaughani: often large and strong, globose; spire elevated; sutural channel about 0·5 mm. wide, sometimes less; outer lip not noticeably retracted to suture.

Sulconacca suturalis (Hutton). (Plate 57, fig. 1.)

1877. *Lunatia suturalis* Hutton, *Trans. N.Z. Inst.*, vol. 9, p. 597, pl. 16, fig. 11.
1915. *Ampullina* (*Megatylotus*) *suturalis* (Hutton) Suter, *N.Z. Geol. Surv. Pal. Bull. 3*, p. 10.

Shell rather small, globose; spire gradate, a little over half the height of aperture; whorls 5, convex; suture fairly deeply and widely channelled (0·75 mm. wide in a shell of 10 mm.); whorls smooth and polished, with some obsolete microscopic spirals, crossed by very fine growth-lines; aperture semilunar, effuse below; outer lip with a shallow sinus in middle and slightly retracted to suture on upper part of whorl, inclined 20° from vertical; inner lip thin; umbilicus fairly wide but varying somewhat, bounded by a shallow furrow.

Neotype in collection of Mr. R. S. Allan, Dunedin.

Height, 12 mm.; diameter, 10 mm.

Locality.– Greensand, McCullough's Bridge, Waihao River.

Hutton's type, which was stated to be from Waihao (*i.e.*, the greensands), has been lost (Suter, 1915, p. 10). Since several similar species occur at this and other localities (all previously classed *A. suturalis*), it is therefore important to choose a suitable neotype. Obviously, if there were no impediment, the specimen used by Suter for his description should be taken, but unfortunately the locality is doubtful. The tablet is labelled "Waihao," but the form and preservation of the shell, and the matrix within it, were noticed by Mr. Allan to be different from such as are found in the greensand there. Similar shells and matrix occur above the limestone of the Pareora River, at Blue Cliffs and Mount Horrible, so it seems likely that the specimen was from one of these localities and had become mixed with a Waihao collection. Perhaps it is really from the Waihao Valley, but from a horizon above the limestone. Hutton distinctly says his Waihao shells were from the greensand, so unless his actual type can be produced the neotype should be chosen from that bed. His figure is of a globose shell with a low spire, and of large dimensions, and does not look very like a Waihao shell. Indeed, it is more like Suter's specimen, so the error of locality may have crept in before Hutton handled the specimen, and Suter may have actually used the type for his description without knowing it.

Since there are no means of finding out which is the correct solution, and since Hutton gave the locality as "Waihao greensand," it seems advisable to select a neotype from the several species that occur in that bed. Therefore the specimen from Mr. Allan's collection, figured on Plate 57, fig. 1, is here chosen. We know that Hutton had some specimens from McCullough's Bridge, because he speaks of a small shell with a very strong umbilical ridge. This can be none other than *N. haasti*.

Sulconacca prisca n. sp. (Plate 57, fig. 2.)

Shell rather small, subglobose, with somewhat flattened sides; spire gradate, about one-half the height of aperture; whorls 5 or 6, with some

microscopic spirals crossed by fine growth-lines; suture deeply and widely channelled (about 1 mm. wide in a shell of 10 mm. diam.); aperture semilunar, narrower above; outer lip slightly concave, retracted to suture above; inner lip with thin enamel on parietal wall; umbilicus widely open, bounded by low ridge outside which is broad sulcus caused by notch in anterior margin of aperture; on umbilical side of this notch is a thickening of margin which gives rise to ridge.

Holotype in collection of Mr. R. S. Allan.

Height, 11 mm.; diameter, 10 mm.

Localities.—Greensand, Waihao Downs (type); 164, greensand above coal-beds, Kakahu.

Sulconacca compressa n. sp. (Plate 57, fig. 3.)

Shell rather small, ovate, with compressed sides; spire gradate, about one-half the height of aperture; whorls 5, with microscopic spirals crossed by fine growth-lines; suture channelled (about 0·75 mm. in a shell of 10 mm. diameter); aperture ovate; outer lip slightly concave and gently retracted to suture, inner lip with thin enamel on parietal wall; umbilicus narrow, bounded by low ridge and shallow furrow.

Holotype in collection of Mr. H. J. Finlay.

Height, 11 mm.; diameter, 9 mm.

Locality.—7c, Clifden.

This species is distinguished from *S. prisca* by its more compressed shape, slightly narrower channel, ovate aperture, narrow umbilicus, and weak circum-umbilical sulcus.

Sulconacca vaughani n. sp. (Plate 57, fig. 4.)

Shell of moderate size, globose, robust; spire gradate, from one-half to two-thirds the height of aperture; whorls 6; protoconch of two smooth convex whorls with minute nucleus and with impressed suture which changes suddenly to a channelled one at commencement of the neanic shell; sutural channel when shell is 10 mm. in diameter is from 0·3 mm. to 0·5 mm. wide and about half this in depth; whorls smooth and polished, with some fine spirals crossed by inconspicuous growth-lines; aperture semilunar; outer lip straight, not retracted to suture except from bottom of channel, inclined about 20° from vertical; inner lip with relatively thick callus on parietal wall, thin and sharp on umbilical wall, then thickened again below; umbilicus moderate, bounded by furrow of variable depth which meets anterior margin of aperture at a shallow notch; on inner side of furrow is a more or less prominent ridge or basal limb.

Holotype in collection of New Zealand Geological Survey.

Height, 14·5 mm.; diameter, 12 mm.

Localities.—1161, Pakaurangi Point (type); 166, Mount Horrible, Pareora River; Otiake beds, Trig. Z, Otekaike; 1172, Pukeuri, Oamaru; uppermost Mount Brown beds, Weka Pass [= *N. australis* (in part) of Suter, 1921, p. 43]; 882, sandy claystone above limestone, Waitomo Valley; 862, argillaceous sandstone, head of Waimata River; uppermost Mount Brown beds, Weka Pass (J. A. Thomson); Target Gully, Oamaru; Rifle Butts, Oamaru; Awamoa; 4B, 6A, 6C, Clifden, Southland (H. J. Finlay); Ardgowan; 1144, Okoko Road, one mile west of Pehu Trig., Upper Waitara; 1142, near junction of Tangitu Stream and Waitara River (L. I. Grange).

Distinguished from *suturalis* by its large size, slightly narrower sutural channel, and straight outer lip not retracted to suture except from bottom

of channel. In *S. suturalis* and *S. prisca* the lip is noticeably though gently retracted for a considerable distance.

It is possible that another specific division can be made for those shells with a narrower sutural channel than the type. This narrowing is greatest in shells from the Waitara beds, which are also stratigraphically the youngest, but more material than is at the writer's disposal is required.

The species is named in honour of Dr. T. Wayland Vaughan, of the United States Geological Survey, who collected at Pakaurangi and many other Tertiary localities in 1923.

3. Genus UBER Humphreys, 1797* (= *Polinices* Montfort, 1810).

Shell ovate to subcylindrical; sutures tangential; aperture with a thick parietal callus coalescing with the funicle and invading the umbilicus, which is sometimes completely filled, sometimes left widely open; operculum corneous.

Type: *Nerita mammilla* Linné.

KEY TO SPECIES.

huttoni: very large, sometimes ovate, generally subcylindrical with a low spire, umbilicus closed or shallow, never penetrating.

sagenus: moderate size, roundly oval, flattened; umbilicus wide, variable; aperture greatly inclined.

mucronatus: moderate size, longitudinally oval, apex mucronate, umbilicus closed, callus very thick.

intracrassus: large, subcylindrical, summit flat; callus enormous, filling suture and umbilicus.

lobatus: moderate size, ovate; umbilicus closed; callus fairly thick with two converging grooves, interspace lobed.

unisulcatus: moderate size, ovate; umbilicus closed; callus with only one groove at base, close and parallel to apertural margin.

waipaensis: small, ovate; umbilicus closed; callus like *unisulcatus*; nucleus of protoconch minute.

chattonensis: large, ovate; umbilicus open below; callus joined to parietal wall for full length, no groove.

propeovatus: large, broadly ovate; umbilicus open below; callus projecting in a prominent angle over funicle, junction marked by deep groove.

waipipiensis: large, broadly ovate; umbilicus with large opening left between parietal wall and callus.

pateaensis: large, broadly ovate; umbilicus widely open, funicle narrow; callus not advancing far down and ending in a lobe.

ovuloides: large, ovate; umbilicus almost closed by callus and wide funicle, leaving only narrow slit.

finlayi: fairly large, ovate; callus rather narrow, but often filling umbilicus, which is narrow; inner margin of aperture strongly sinuous.

seniculus: very small, ovate; callus with parietal side straight; umbilicus generally a shallow groove.

kaawaensis: very small, broadly ovate; callus with parietal side concave; umbilicus generally quite filled.

esdailei: small, broadly ovate; umbilicus a narrow slit, not penetrating; callus with single transverse groove.

incertus: small, ovate; umbilicus closed; callus with single groove, above which it projects on to parietal wall.

modestus: small, ovate; umbilicus closed; callus broadly rounded off below, grooves inconspicuous.

obstructus: moderate size, ovate; umbilicus generally closed or with a narrow chink; callus narrow with two transverse almost parallel grooves.

scalptus: moderate to small, broadly ovate; transverse grooves low down; aperture greatly inclined.

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* See HEDLEY, C., Some Naticoids from Queensland, *Rec. Aust. Mus.*, vol. 14, No. 3, 1924, an article which the author has been enabled to see since the reading of this paper.

The last eight species form a distinct group. They are smaller and have a more restrained apertural callus than the others The umbilicus is restricted and generally quite filled by the narrow funicle and callus. on which there are two almost parallel grooves (sometimes one or both obsolete). The arrangement of the umbilical callus is rather like that in the subgenus *Mammilla*, which, however, has a more distended aperture. It is possible that the relationship is closer to it than to *Uber* s. str.

Uber huttoni (von Ihering). (Plate 58, fig. 10.)

1873. *Natica solida* Sowerby: Hutton, *Cat. Tert. Moll.*, p. 9 (not of Sowb.).
1886. *Natica solida* Hector, *Outline of N.Z. Geol.*, p. 51, fig. 9, No. 19.
1886. *Natica* (*Neverita*) *gibbosa* Hutton, *Trans. N.Z. Inst.*, vol. 18, p. 334 (not of Lea).
1907. *Polynices huttoni* v. Ihering, *Ann. d. Museo Nac. de Buenos Aires*, serie 3, tomo 7, p. 154, pl. 5, fig. 16.
1915. *Polinices gibbosus* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull. 3*, p. 9, pl. 5, figs. 1, 2.

Type in Museo Nacional, Buenos Aires.

Height, 68 mm.; diameter, 64 m. (taken from Hutton's plesiotype of *N. solida* Sowb. = *N. darwini* Hutt.).

Localities.—Broken River, Trelissick Basin (type); 165, White Rock River, Pareora; Target Gully shell-bed, Oamaru; Tangarakau River, two miles below large waterfall (Mokau beds); Maungamatukutuku, Tutamoe (Tawhiti sandstone); Taumatamaire Hill (Mahoenui beds); 44, *Conus* beds, Brewery Creek, Mokihinui River; Chatton, Southland, sharp-spired form (R. A. Sutherland); Waikaia, sharp-spired form; 6B, 6C, 6D, 7B, 7C, 8A, Clifden, Southland.

Hutton recorded the species as occurring in the Pliocene at Matapiro, but his specimen, if correctly identified, was probably from some other locality. This type of *Uber* was extinct in New Zealand long before the deposition of the Matapiro beds (= Nukumaruian).

Suter generally applied the specific name *huttoni* to shells with a widely open umbilicus not invaded by callus, such as those (*N. suteri*) from locality 476, Kekenodon beds, Waitaki Valley. The shell figured by von Ihering, however, is from Broken River, Trelissick Basin, and has the heavy callus and cylindrical shape of Hutton's *gibbosus*. The two names are therefore synonymous; and, as *N. gibbosa* was already occupied by Lea for a North American Eocene fossil when Hutton proposed it, von Ihering's *U. huttoni* must be used.

Round *U. huttoni* are grouped a large number of variable forms, for which satisfactory specific divisions have not yet been found. Among the material available no absolute line could be drawn between such extreme forms as *U. unisulcatus* and *U. intracrassus* (= *N. callosa* Hutt.). At Chatton there is a large shell with a high, sharp spire; at Waikaia and in several horizons at Clifden are somewhat similar though smaller ones apparently grading into a much broader type with a low spire. Perhaps some of the differences are due to sex, but there is variation in shells from different localities. Both forms are represented at Target Gully with slight differences in outline. The shells of White Rock River, Pareora, are of more uniform character, being cylindrical in shape, with a low spire, and reaching a very large size (like the typical Broken River specimens). There is considerable variation, however, in the comparative length and callosity, a process carried to extreme in the *U. intracrassus*

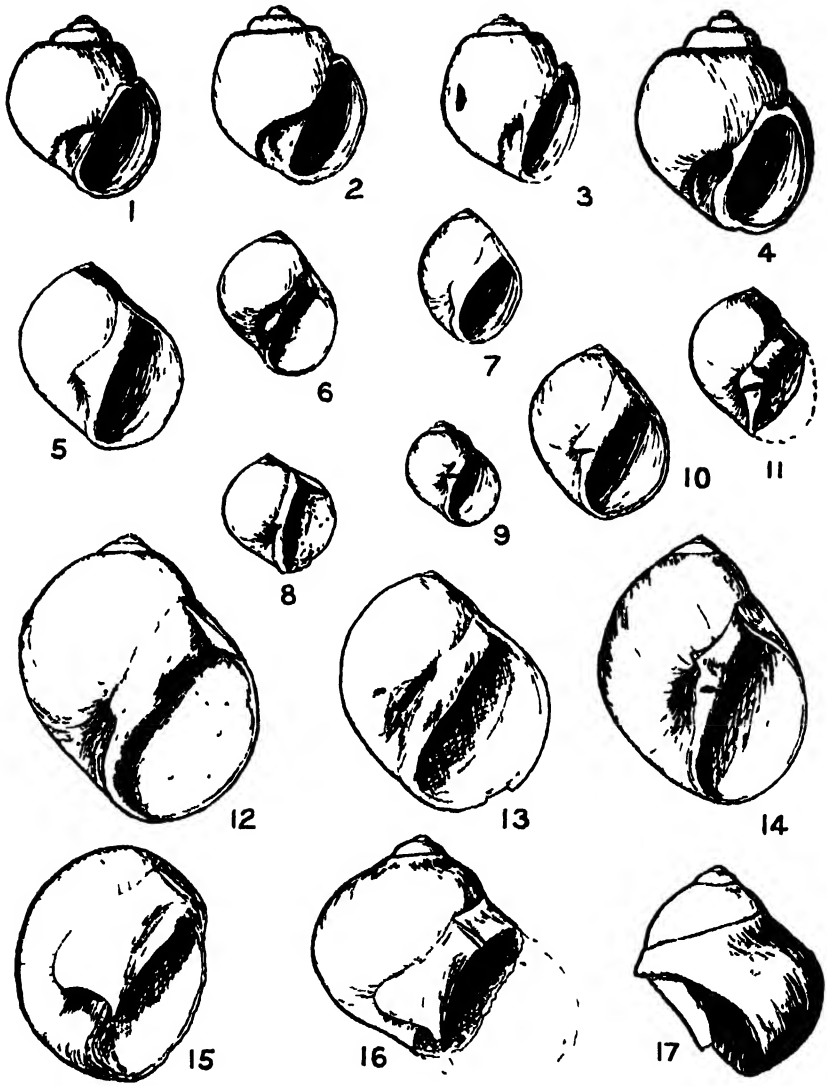


FIG. 1.—*Sulconacca suturalis* (Hutton). neotype × 2
FIG. 2.—*Sulconacca prisca* n. sp : holotype. × 2.
FIG. 3.—*Sulconacca compressa* n. sp. : holotype × 2
FIG. 4.—*Sulconacca vaughani* n. sp. : holotype. × 2
FIG. 5.—*Uber kaawaensis* n. sp. : holotype × 4.
FIG. 6.—*Uber senisculus* n. sp. : holotype. × 3.
FIG. 7.—*Uber modestus* n. sp. : holotype. × 1.
FIG. 8.—*Uber finlayi* n. sp. : paratype × 1.
FIG. 9.—*Uber esdailei* n. sp. : holotype × 1
FIG. 10.—*Uber incertus* n. sp. : holotype. × 1.
FIG. 11.—*Uber scalptus* n. sp. : holotype. × 1.
FIG. 12.—*Uber finlayi* n. sp. : holotype. × 1.
FIG. 13.—*Uber finlayi* n. sp. : paratype. × 1.
FIG. 14.—*Uber obstructus* n. sp. : holotype. × 1.
FIGS. 15, 16, 17.—*Uber (Neverita) pontis* n. sp. : holotype. × 3.

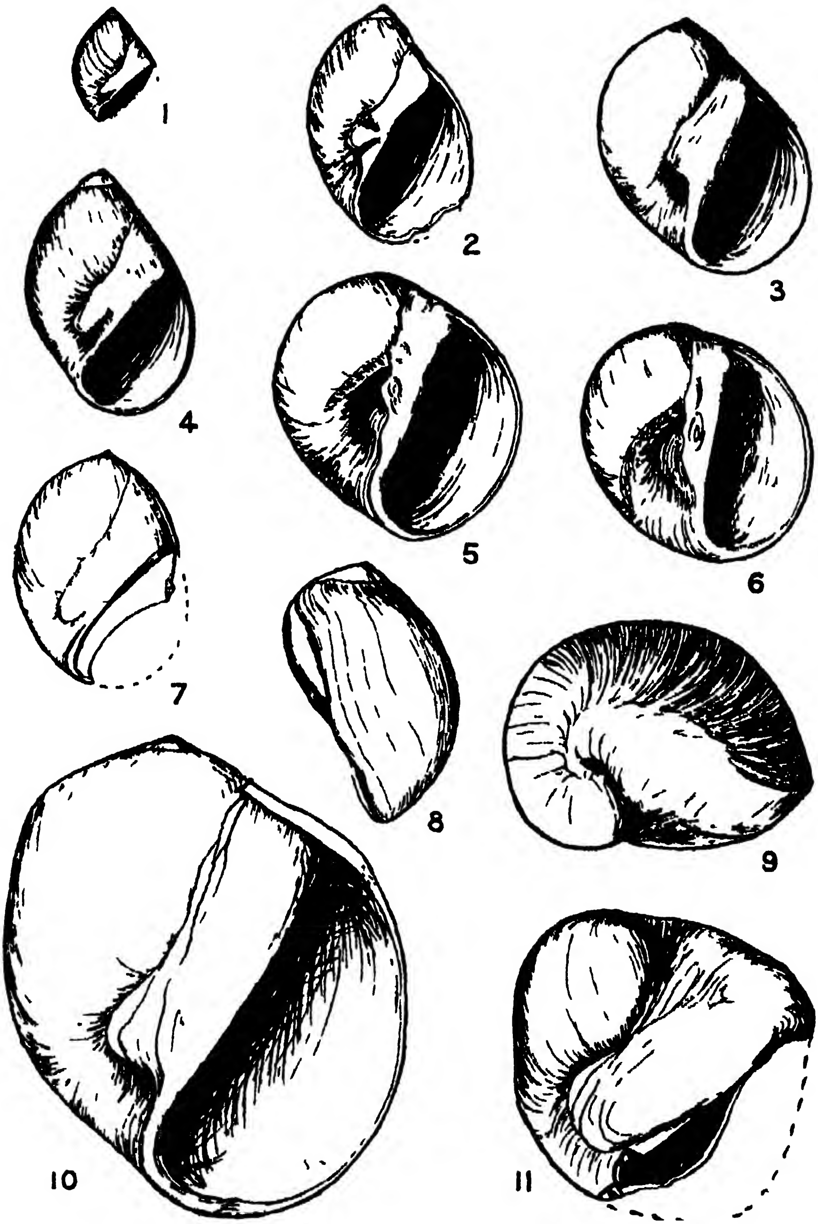


Fig. 1.—*Uber waipaensis* n. sp., holotype. × 1.
Fig. 2.—*Uber lobatus* n. sp.: holotype. × 1.
Fig. 3.—*Uber chattonensis* n. sp.: holotype. × 1.
Fig. 4.—*Uber unisulcatus* n. sp.: holotype. × 1.
Figs. 5, 8.—*Uber sagenus* (Suter): holotype. × 1.
Fig. 6.—*Uber sagenus* (Suter): topotype. × 1.
Fig. 7.—*Uber mucronatus* n. sp.: holotype. × 1.
Figs. 9, 11.—*Uber intracrassus* (Finlay): lectotype. × 1.
Fig. 10.—*Uber huttoni* (v. Ihering), White Rock River. × 1.

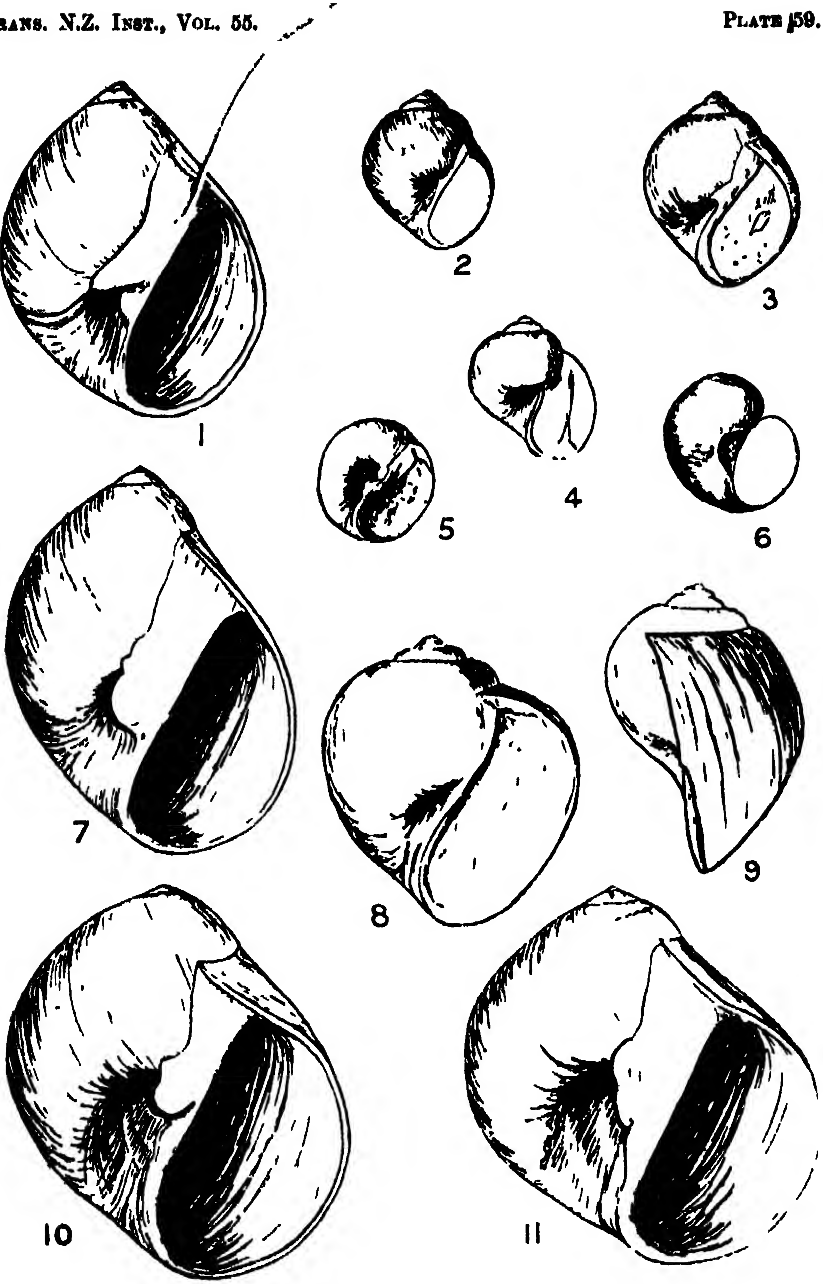
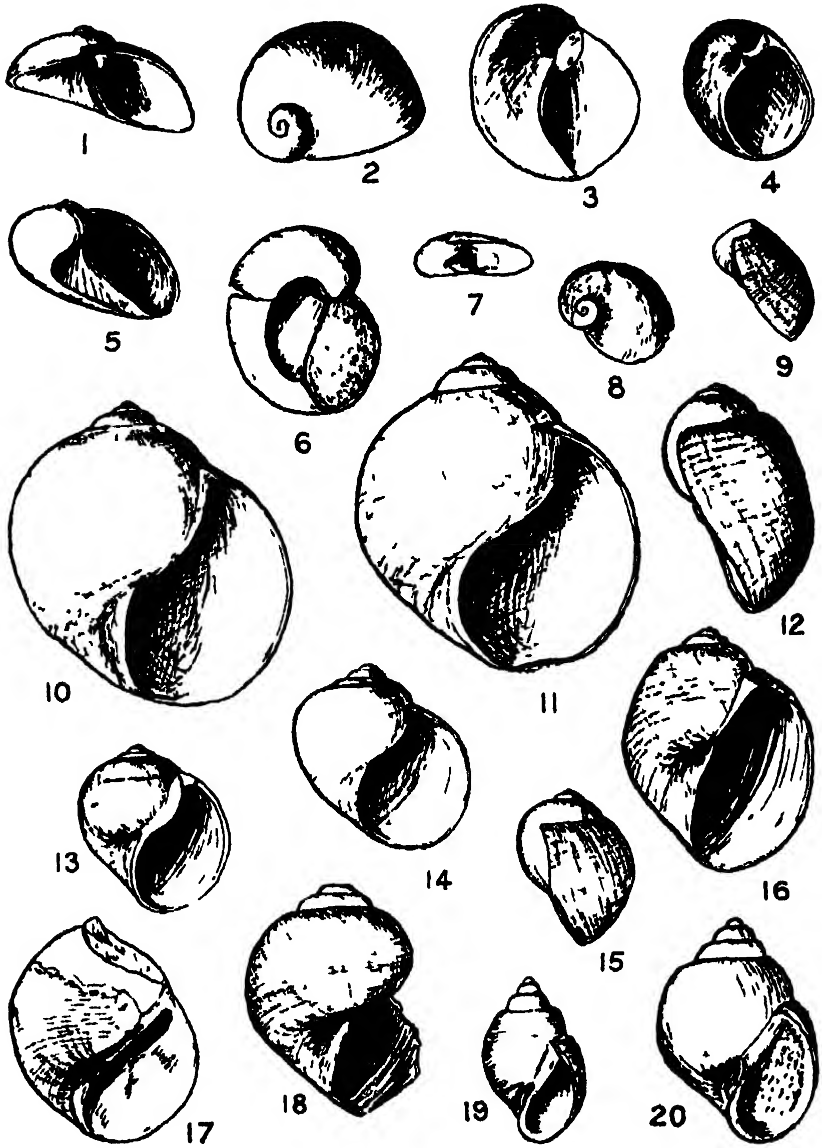


FIG. 1.—*Uber propeovatus* n. sp. : holotype. × 1.
FIG. 2.—*Uber (Euspira) firmus* n. sp., loc. 480, Waihao. × 1.
FIG. 3.—*Uber (Euspira) firmus* n. sp. : holotype. × 1.
FIG. 4.—*Uber (Euspira) lateapertus* n. sp. : holotype. × 1.
FIG. 5.—*Uber (Euspira) lateapertus* n. sp. : paratype. × 1.
FIG. 6.—*Uber (Euspira) lateapertus* n. sp. : paratype. × 2.
FIG. 7.—*Uber ovuloides* n. sp. : holotype. × 1.
FIGS. 8, 9.—*Uber (Euspira) fyfei* n. sp. : holotype × 1
FIG. 10.—*Uber pateaensis* n. sp. : holotype. × 1.
FIG. 11.—*Uber waipipiensis* n. sp. : holotype. × 1



Figs. 1, 2, 3.—*Micreschara (Macromphalina) huttoni* n. mut.: holotype. × 5.
Figs. 4, 9. *Sinum fornicatum* Suter.: holotype × 1.
Figs. 5, 6.—*Micreschara (Macromphalina) auriformis* n. sp.: holotype. × 5.
Figs. 7, 8.—*Sinum infirmum* n. sp.: holotype. × 4.
Fig. 10.—*Globisinum venustum* (Suter) holotype. × 1.
Fig. 11.—*Globisinum drewi* (Murdoch): holotype. × 1.
Figs. 12, 16.—*Sinum (Eunaticina) cinctum* (Hutton): holotype. × 1.
Fig. 13.—*Globisinum miocaenicum* (Suter), Parson's Creek. × 1.
Fig. 14.—*Globisinum undulatum* (Hutton), Wanganui (? Landguard Bluff). × 1.
Fig. 15.—*Globisinum drewi* (Murdoch), juv. Kai Iwi. × 1.
Fig. 17.—*Globisinum spirale* (Marshall): holotype. × 1.
Fig. 18.—*Globisinum elegans* (Suter): holotype. × 2
Fig. 19.—*Amauropsella maior* (Marshall): holotype. × 2.
Fig. 20.—*Amauropsella teres* n. sp.: holotype. × 2.

of Lower Waipara Gorge, where greatly elongated specimens are seen grading into typical *intracrassus*.

At many localities along the east coast of the North Island, in beds somewhat younger than the Awamoan, occur rather smaller shells, generally with a mucronate apex (*U. mucronatus*). Some are of an elongate-oval shape, while others are more like the typical *U. huttoni*. On the west coast (North Island) those of typical shape do not rise any higher than the Mokau beds, but in the Onairo fauna appears an acuminate-spired ovate shell (*U. unisulcatus*) only a little more slender than some of those from Waikaia and Clifden.

The forms which have been given specific rank are: -

(1.) *U. huttoni*.

(2.) *U. intracrassus*. The shell on which the name is founded is of such extreme development as to merit specific separation. There is no evidence that intermediate forms occur at the type locality; perhaps the Waipara Gorge is intermediate in age between Broken River and Castle Point. In any case, even when the shape is the same as that of *U huttoni*, the apertural callus is noticeably thicker.

(3.) *U. unisulcatus*. This is only slightly more slender than ovate specimens of *U. huttoni* from Waikaia. At the lower horizon, however, there is an intergradation with broader forms, but at the higher these are absent.

(4.) *U. mucronatus*. Although depressed adult forms are equalled by high forms of young *U. huttoni*, the callus on the former is considerably thicker than that on the latter.

Tate (1893, p. 320, pl 6, fig. 4) records *Natica gibbosa* Hutton from a "locality not actually known, but reported a well-sinking in the Murray Desert." The disposition of the apertural callus is not the same as in the New Zealand species. for it is much wider over the umbilicus than on the parietal wall, where it is relatively narrow. It is most likely that a critical examination of the actual specimen would show other important differences, and that it should be classed as a distinct species.

Uber intracrassus (Finlay). (Plate 58, figs. 9, 11.)

1873. *Natica* (?) *callosa* Hutton, *Cat. Tert. Moll*, p 9 (not of Sowerby).
1914. *Polinices callosus* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull.* 2, p. 4.
1924. *Polinices intracrassus* Finlay, *Proc. Malac. Soc.*, vol 16, p. 101.

Shell large, subcylindrical, summit flatly convex; spire concealed by body-whorl, which has the left-to-right diameter much greater than that from back to front; apertural callus enormous, completely filling the umbilicus and for last half of body-whorl occupying suture and extending across flat summit to apex.

Holotype in collection of New Zealand Geological Survey.

Height, 37 mm. (estimated); diameter, front to back 29 mm., left to right 39 mm.

Localities.—Castle Point, Wellington (?) (type); County Council quarry, Maungapakeha Stream, six miles west-south-west of Tinui, Castle Point County; Lower Waipara.

The name *N. callosa* is preoccupied by Sowerby; therefore Finlay rightly changed Hutton's name to *intracrassus*. Hutton was uncertain about the locality of his types, but Castle Point is probably correct in a broad sense. The richly fossiliferous beds at Castle Point itself (Geol.

Surv. loc. 81) have a Wanganuian fauna; this type of *Uber* belongs to a lower horizon, and probably came from the "Taipo" beds in the neighbouring district.

Uber mucronatus n. sp. (Plate 58, fig. 7.)

Shell of moderate size, oval; spire short, acute or often mucronate; outer lip not greatly inclined; apertural callus large, sealing umbilicus, lower end of callus lobed and bounded by very deep groove on apertural side; sometimes when the callus is not fully developed there remains slight umbilical opening which resembles that of *U. propeovatus.*

Type in collection of New Zealand Geological Survey.

Height, 29 mm.; diameter, 23 mm.

Localities.—1037, Hurupi Creek, Palliser Bay (type); 882, argillaceous sandstone, Waitomo; 862, head of Waimata River, Gisborne; 1121, Wharekahika River, East Cape; Muddy Creek, Arowhana; 1156, Awatere Mouth, East Cape; upper grey marls, south cliff, north branch of Dee River (= *P. gibbosus* of Suter, 1921, p. 82).

Uber unisulcatus n. sp. (Plate 58, fig. 4.)

Shell of moderate size, elongate, ovate; spire high, conic, slightly mucronate; apertural callus well developed, filling umbilicus with a somewhat narrow lobe bounded by deep broad groove which lies very close to inner margin of aperture, but is not quite parallel to it; outer lip slightly retracted to suture.

Type in collection of New Zealand Geological Survey.

Height, 31 mm.; diameter, 23 mm.

Localities.—1136, Mangare Road, near Mangaone Stream, Upper Waitara Survey District (type); 1128, Putiki Stream, Tongaporutu River; 1113, Rapanui Island, Taranaki (L. I. Grange).

Uber waipaensis n. sp. (Plate 58, fig. 1.)

Shell small, plump, ovate, of about five and a half whorls; spire acute; protoconch very small; outer lip inclined at 30° from vertical, retracted above to suture, but otherwise straight; apertural callus thick, completely covering umbilicus; a shallow groove ascends from base of callus near and parallel to apertural margin.

Type in collection of New Zealand Geological Survey.

Height, 15 mm.; diameter, 13 mm.

Localities.—1029, one mile north-north-east of limestone-crushing plant, Alexandra Survey District; Pourakino, Riverton (H. J. Finlay).

The disposition of the callus is much the same as that of *U. unisulcatus*, but the shell is more globose and the protoconch as well as the whole shell is much smaller. There is also considerable resemblance to *U. mucronatus*, which, however, is larger and has a more nearly vertical outer lip.

Uber lobatus n. sp. (Plate 58, fig. 2.)

Shell of moderate size, elongate, ovate; spire acuminate; apertural callus comparatively narrow, but sealing umbilicus by a lobe bounded below by deep groove which is inclined at about 45° to apertural margin; somewhat higher there is a wider and shallower groove at right angles

to apertural margin where it meets lower groove, space between the two being occupied by lobe of callus; the inner margin of aperture noticeably sinused about top of funicle.

Type in collection of New Zealand Geological Survey.

Height, 30 mm.; diameter, 22 mm.

Localities.—165, White Rock River, Pareora (type); Target Gully, Oamaru; 1075, argillaceous sandstone, 12 chains north-north-west of Rangiriri Trig., Piopiotea West Survey District (Mohakatino base); 649, Paparoa Rapids, Wanganui River; 475, Mount Harris, South Canterbury (= *P. gibbosus* and *P. ovatus* of Suter, 1921, p. 64), 958, Rifle Butts, Oamaru, bed A, overlying Oamaru stone (= *P. gibbosus* of Suter, 1921, p. 86); 458, Pareora (= *P. gibbosus* of Suter, 1921. p. 58); Awamoa (H. J. Finlay); Wharekuri ? horizon (H. J. Finlay).

Uber sagenus (Suter). (Plate 58, figs. 5, 6, 8.)

1917. *Polinices (Neverita) sagenus* Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 10, pl. 3, fig. 3.

The holotype has a widely open umbilicus which reaches up to apex of shell, but no other specimen has been seen which agrees exactly with this shell. The large species, so common in the Lower Wanganuian beds at Waipipi, Hawera, Waingongoro, &c., and identified by Suter (1921, p. 25), also by Marshall and Murdoch (1920, p. 125; 1921, p. 87), as *P. sagenus*, is in this paper named *U. waipipiensis;* for, while it resembles *sagenus* in umbilical development, its shape is quite different. The most important difference, however, is in the inclination of the outer lip. In *U. waipipiensis* it is inclined at about 26° from the vertical, while in *U. sagenus* the angle is 37°.

The specimen figured on Plate 58, fig. 6, is a topotype of *U. sagenus*, and, as may be seen, has the same outline and same disposition of callus. The inclination of outer lip is also about 37° from the vertical. There can therefore be little doubt that the two shells are conspecific. One important difference exists, however: in the type specimen the umbilicus is wide and deep, extending almost to the spire; in the other it is quite shallow, and when the shell was a quarter of a whorl younger must have been completely closed. The only other specimen seen which agrees with these two in outline, aperture, and callus is from Trelissick Basin. In this specimen the umbilicus is for the most part shallow, as in the second Pareora specimen, but there is a very small chink at top penetrating upwards perhaps ⅛ in. Despite these differences the actual appearance of the apertural callus is similar in all cases, and with the great inclination of outer lip justifies specific recognition.

Localities.—165, White Rock River, Pareora; 226, Porter and Thomas Rivers, Trelissick Basin.

Uber chattonensis n. sp. (Plate 58, fig. 3.)

Shell fairly large, ovate; spire sharp, about one-third height of aperture (including callus); whorls 5, rapidly increasing, surface with growth-lines; suture tangential; aperture semilunar; outer lip sinuous, slightly concave in middle, and retracted above to suture; inner lip with thick parietal callus nearly covering umbilicus (which, however, is penetrating), and cemented to parietal wall along its whole outer side; umbilicus with funicle coalescing with callus, line of junction not marked by distinct groove.

Type in collection of Mr. H. J. Finlay.
Height, 32 mm.; diameter, 27 mm.
Locality.—Chatton, near Gore.

This species is very like *U. propeovatus* and *U. ovuloides*. It is distinguished from the former by the absence of deep groove at junction of funicle and callus, also by rather narrower umbilicus; from the latter by the disposition of callus, which is cemented to parietal wall along its whole length.

Uber propeovatus n. sp. (Plate 59, fig. 1.)

Shell large, ovate; spire short, pointed; spire-whorls slightly convex, body-whorl very large; suture tangential; aperture semilunar; outer lip almost straight; umbilicus of moderate width but shallow, and nearly closed by large funicle and apertural callus which projects across and down on to parietal wall; lowest lobe of callus bounded below, where it crosses funicle by deep groove.

Type in collection of New Zealand Geological Survey.
Height, 43 mm.; diameter, 35 mm.
Localities.— 1135, Tirangi Stream, Ngatimaru Survey District, Taranaki (type); 895, Rapanui River mouth, and many other localities in the Tongaporutu and Onairo areas; 679, Waihou, Bay of Plenty; ? 996, Kaawa Creek, south of Waikato River; Marshall's Road, Mangaehu Creek, Waimata River (Tawhiti beds); ? Target Gully (one broken specimen).

Uber waipipiensis n. sp. (Plate 59, fig. 11.)

Shell large, ovate: spire short and broad but pointed; whorls on spire lightly convex, body-whorl very large; suture tangential; aperture semilunar; outer lip slightly sinuous; umbilicus widely open and deep, extending directly up towards spire; funicle large but not extending more than half-way across umbilicus; apertural callus overlapping funicle above on to parietal wall but not below.

Type in collection of New Zealand Geological Survey.
Height, 49 mm.; diameter, 47 mm.
Localities.— 1101, Waipipi Beach, north of Wairoa Stream, Waverley (type); 875, 1172, mouth of Waingongoro River, Taranaki; 876, 1173, Waihi Stream, Hawera Beach; 126 (? Thomson coll.), Awatere Valley, decorticated and fragmentary (= *A. suturalis* of Suter, 1921, p. 30); New River, Westland; ? 154, Kanieri; ? Motunau beds, Weka Pass, B3; 857, above waterfall, Starborough Creek, Awatere (= *P. huttoni* of Suter, 1921, p. 30); 858, below waterfall, Starborough Creek, Awatere (= *P. huttoni* of Suter, 1921, p. 31).

Uber pateaensis n. sp. (Plate 59, fig. 10.)

Shell large, ovate; spire short and broad but pointed; whorls on spire lightly convex, body-whorl very large; suture tangential; aperture semilunar; outer lip slightly sinuous; umbilicus wide but shallow; funicle narrow below but widening suddenly above; apertural callus moderate, extending down over top of funicle as short rounded lobe bounded below by deep groove.

Type in collection of New Zealand Geological Survey.
Height, 50 mm.; diameter, 45 mm.
Locality.— 1171, Patea.

Uber ovuloides n. sp. (Plate 59, fig. 7.)

1873. *Natica (Mamilla) ovata* Hutton, *Cat. Tert. Moll.*, p. 9, in part (not of Klipstein).
1886. *Natica ovata* Hector, *Outline N.Z. Geol.*, p. 5, fig. 9, No. 15.
1893. *Natica (Mamilla) ovata* Hutton, *Macleay Mem. Vol.*, p. 55, pl. 7, fig. 40.

Shell large, ovate; spire acuminate; umbilicus with large funicle; apertural callus thick, projecting slightly over funicle but not reaching across umbilical depression, thus leaving a diagonal umbilical slit; a groove in callus above lower part of funicle meets apertural margin at angle of 45°.

Type in collection of New Zealand Geological Survey.

Height, 50 mm.; diameter, 38 mm.

Localities.— 1171, Patea; 1172, Waingongoro Mouth.

Great confusion has arisen over this species through the non-designation of a definite holotype. Hutton's original description gave as localities "Shakespeare Cliff; Callaghan's Creek; Motunau (L); Kanieri; Broken River (U and L); Weka Pass (M); Oamaru; Awamoa; Lyndon," and the specimen preserved in the collection illustrating the *Catalogue* is labelled "Shakespeare Cliff." This shell was figured by Suter and designated by him "holotype." Although Thomson (preface to *Pal. Bull.* 2) thought it possible that Hutton selected holotypes for his species, the writer cannot agree with this. In addition to the contrary evidence cited by Thomson, the following points are also important: No mention is ever made by Hutton of the word "type"; in many cases a number of specimens were preserved; the illustrating specimen often does not agree with the dimensions quoted. It would thus be better to consider the types revised by Suter as lectotypes, except where only one locality and one specimen are represented. The use of "Shakespeare Cliff" in this instance is in a very wide sense, because the large *Uber* spp. do not reach any higher in the stratigraphical column than the Waitotara series, and Hutton's specimens probably came from Patea. In any case, Suter's type was wrongly attributed by him to the Wanganui district; a microscopic examination of the matrix shows that it is from locality 227, Kanieri, Westland. Moreover, it is specifically distinct from any of the Waitotaran *Uber*, and in the collection from 227 there are about fifty specimens agreeing in all essentials with this one. The dimensions given by Hutton are 1·45 in. × 1·25 in. (= 37 mm. × 32 mm.), but those of Suter's type are 36 mm. × 28 mm. The form that has generally been considered as the typical *P. ovatus* is the one from Patea which has the umbilicus almost filled by a large funicle and apertural callus, leaving always a narrow, slightly inclined penetrating slit. Both Hector's and Hutton's figures show this type of shell, so that on these grounds alone Suter's choice of a type could have been upset. The position is, however, simplified by the fact that *Natica ovata* is preoccupied by Klipstein (*Beitrage zur geologischen Kentniss der ostlichen Alpen*, 1843), so that we can start again with fresh specific names.

Uber finlayi n. sp. (Plate 57, figs. 8, 12, 13.)

Shell fairly large, ovate: spire sharp but not high; whorls about 6, slightly convex in spire; surface with numerous growth-lines; suture tangential, aperture semilunar; outer lip lightly sinuous, retracted to suture, inclined about 35° from vertical; inner lip sinuous with fairly thick callus coalescing with and little wider than funicle, which almost or quite fills the rather narrow umbilicus.

Type in collection of Mr. H. J. Finlay.

Height, 37 mm.; diameter, 34 mm.

Localities.—Boulder Hill, near Dunedin (type); Wangaloa.

This species presents such a variety of form that it is difficult to give an adequate description embracing the whole. In youth the shape is very broadly ovate or oval and funicle relatively narrow, being merely a thickening of the whole front part of inner margin; the parietal callus is wider and contracts suddenly to funicle (see Plate 57, fig. 8). This stage is represented at a higher horizon by *U. incertus* of Target Gully. The umbilicus is a shallow scarcely-penetrating groove. Later the shell becomes more ovate, and the sharp angle showing junction between parietal callus and umbilicus disappears, and a condition not unlike *U. modestus* is produced where umbilicus is quite filled. A continuation of this stage to the adult is represented by the holotype, but in many cases the funicle narrows with growth so that an umbilical groove is again formed. The top of this groove is sometimes penetrating. This form (Plate 57, fig. 13) is extremely like *U. obstructus.* Suter classed the species under *P. gibbosus*, presumably because umbilicus was sealed; but the disposition and manner of growth of callus and funicle are quite different. The well-marked sinus at posterior end of inner margin is also distinctive of the older species.

The great inclination of outer lip separates *U. finlayi* from *U. obstructus* and *U. incertus;* also absence of grooves across callus.

Uber seniculus n. sp. (Plate 57, fig. 6.)

Shell very small, ovate, solid; spire one-half height of aperture; whorls 5, slightly convex on spire, suture tangential; aperture semilunar to ovate; outer lip straight or slightly concave, gently retracted to suture; inner lip with moderate callus, coalescing below with large funicle; umbilical opening a rather shallow groove bounding funicle, but penetrating above.

Type in collection of Mr. H. J. Finlay.

Height, 6 mm.; diameter, 5 mm.

Locality.—Boulder Hill.

This shell looks like a miniature *U. finlayi*, but is certainly not the young of that species, for it has too many whorls; also, the young of *U. finlayi* are more globose and do not have such a wide funicle or umbilical opening.

Uber kaawaensis n. sp. (Plate 57, fig. 5.)

Shell very small, broadly ovate; spire less than half the height of aperture; whorls 4½, slightly convex on spire; suture tangential; aperture semilunar; outer lip almost straight, antecurrent to suture; inner lip with fairly thick callus, which has a convex parietal boundary and is much wider over umbilicus, where it coalesces with funicle and generally completely fills the opening.

Type in collection of New Zealand Geological Survey.

Height, 6 mm.; diameter, 5·5 mm.

Locality.—996, Kaawa Creek, Waikato (Dr. J. Henderson).

This species strongly resembles *U. seniculus*, but the umbilicus is typically much more calloused; also the parietal boundary of the callus is convex, not straight as in Boulder Hill species. It is the *P. amphialus* and probably the *N. australis* of Bartrum (1919, p. 105).

Uber esdailei n. sp. (Plate 57, fig. 9.)

Shell small, broadly ovate; spire moderate; spire-whorls convex, somewhat depressed below suture which is almost tangential; outer lip much inclined; apertural callus relatively narrow; umbilicus almost filled by funicle, but there is a narrow shallow depression; a deep groove crosses callus about top of funicle, and above this the apertural margin inclines well forward.

Type in collection of New Zealand Geological Survey.

Height, 14·5 mm.; diameter, 13 mm.

Localities.— 1100, conglomerate band in Waiarekan tuffs, quarter-mile west of Lorne, North Otago (probably the same as Geol. Surv. loc. 831, collected from by T. Esdaile); Trig. M, Totara (Suter, 1921, p. 88, *P. gibbosus*).

Remarks.— Distinguished from others of the group by the well-inclined aperture, and single transverse groove on callus.

Uber incertus n. sp. (Plate 57, fig. 10.)

Shell of only moderate size, ovate; spire short, acuminate; suture tangential; aperture semilunar; outer lip inclined; apertural callus moderate, extending down and covering umbilicus, bounded below by a groove traversing a very narrow funicle, and projecting above this groove over to outer wall of umbilicus.

Type in collection of New Zealand Geological Survey.

Height, 22 mm.; diameter, 18 mm.

Localities.—Target Gully (type); 1161, Pakaurangi Point.

The *Polinices ovatus* of Suter (1921, p. 51) from "tuffs interbedded with chalk marls, Trelissick Basin," is related to this species, but is too imperfect for definite identification.

Uber modestus n. sp. (Plate 57, fig. 7.)

Shell somewhat small, ovate, sometimes elongate; spire acuminate; outer lip much inclined except near suture, which it meets almost at right angles; apertural callus moderate; umbilicus completely filled by funicle and apertural callus; the outer margin of this callus slightly concave along most of its length, and anterior end somewhat suddenly rounded off, but not forming prominent lobe; there are sometimes two faint transverse grooves converging midway along callus.

Type in collection of New Zealand Geological Survey.

Height, 18 mm.; diameter, 13·5 mm.

Localities.—Target Gully (type); Awamoa; Pukeuri; 1150, Mokau beds, Tongaporutu River, near junction with Papakino River; 919, Mahoenui beds, Awakino Valley (= *P. gibbosus* of Suter); 476, Kekenodon beds, Waitaki River (= *P. gibbosus* of Suter); 483, "Hutchinson Quarry" beds, Wharekuri (= *P. gibbosus* and *P. ovatus* of Suter); 1065, grit band, Kururau Road, Taumarunui; 7c (? 6B, ? 8A), Clifden, Southland (H. J. Finlay); All Day Bay, Kakanui (H. J. Finlay).

Uber obstructus n. sp. (Plate 57, fig. 14.)

1873. *Natica (Mamilla) ovata* Hutton, *Cat. Tert. Moll.*, p. 9, in part (not of Klipstein).

1914. *Polinices (Mamma) ovatus* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull*, 2, p. 21, pl. 17, fig. 1 *a, b*.

Shell of moderate size, ovate; spire acuminate; outer lip well inclined but bending above to meet suture; umbilicus narrow, almost or

completely filled by funicle; apertural callus narrow. restricted, posterior end separated by marked channel from outer lip; two well-marked almost parallel grooves cross callus, the lower about middle of funicle, the other a wide shallow one about top of funicle, and generally coincident with a short spur of callus projecting on to parietal wall.

Holotype in collection of New Zealand Geological Survey.

Height, 36 mm.; diameter, 28 mm.

Localities.—227, Kanieri (type); 6B, 7C, 8A, Clifden, Southland; 1090, "Tawhiti beds," one mile north-west of Kahukura, Block V, Waiapu Survey District; 1157, mouth of Awatere River, East Cape Survey District; 1158, coast, 30–80 chains east of mouth of Awatere River, East Cape Survey District; Otiake (H. J. Finlay).

The holotype is the specimen wrongly stated by Suter to be the type of *Natica ovata* Hutton and to be from "Shakespeare Cliff" (see remarks under *U. ovuloides*). The umbilicus is sometimes completely filled by the funicle, but in others—*e.g.*, the type specimen—there is a narrow chink left. The species is closely related to *U. modestus*, and some border-line specimens are difficult to classify. *U. obstructus* is a larger shell, and the callus tapers off gradually below and is not contracted quickly as in *U. modestus*. Also, even when the umbilicus is sealed, there is a deeper depression in that region.

Uber scalptus n. sp. (Plate 57, fig. 11.)

Shell of moderate size, broadly ovate; spire rather low but pointed; nucleus of protoconoch minute; whorls 5–6, slightly convex on spire, somewhat flattened above; suture tangential; surface with growth-lines getting much stronger as they approach suture; aperture semilunar; outer lip lightly sinuous, strongly retracted to suture which it meets at right angle, inclined about 10° from vertical; inner margin slightly concave; parietal callus moderate, widening over umbilicus and coalescing with funicle, crossed by two grooves and often by other numerous short irregular ones, the two main grooves situated fairly low down, converging; umbilicus completely closed.

Type in collection of New Zealand Geological Survey.

Height (when complete), 20 mm.; diameter, 17 mm.

Localities.—1148, Mangare Road, Upper Waitara (type); 1123, mouth of Tongaporutu River; Rapanui Mouth, north Taranaki; Tongaporutu, 60 chains south of post-office (L. I. Grange).

Distinguished from *U. obstructus* by the greater inclination of the aperture, greater retraction of the outer lip to the suture, and lower situation of the transverse grooves, and from *U. lobatus* by shape, thinner callus, and want of a prominent lobe between the grooves.

a. Subgenus EUSPIRA Agassiz, 1842 (= *Lunatia* Gray, 1847).

Shell globose; spire moderate; whorls convex, surface smooth except for fine growth-lines; aperture semilunar; outer lip straight, slightly retracted to suture, inclined about 30° from vertical; inner margin with light callus on parietal wall; umbilicus open and without any funicle; operculum horny.

Type: *N. labellata* Lamk. (Eocene).

Dall (1909, p. 87) says, "It seems that we shall have to give up *Lunatia* Gray in favour of *Euspira*, which has five years' priority, and of which

both species mentioned when the name was first proposed appear to be *Lunatias;* though species belonging to *Ampullina* seem to have been included later."

KEY TO SPECIES.

fyfei: large (38 mm. high), oval; low spire, sinuous inner margin.
firmus: moderate size (about 20 mm. high), ovate; umbilicus slightly overlain by inner lip.
lateapertus: moderate size (about 20 mm. high), globose; suture impressed or channelled, umbilicus very wide.
vitreus: spire moderate outlines regular; umbilicus small, circular, almost closed in young; lip retracted to suture.
pseudovitreus: spire variable, generally high, spire-whorls strongly convex; lip not retracted to suture.
pukeuriensis: suture impressed.
barrierensis: flattened shape, low spire, very wide umbilicus.

Uber (Euspira) fyfei n. sp. (Plate 59, figs. 8, 9.)

Shell large, oval; spire low, gradate; whorls 6, convex on spire, body-whorl increasing rapidly, extended somewhat anteriorly; surface with growth-lines; suture deeply impressed; aperture large, ovate, channelled posteriorly; outer lip almost straight, with slight posterior sinus antecurrent to suture; inner lip sinuous; parietal wall with thin enamel layer not straightening contour of inner lip; umbilicus open, of moderate size, without funicle or bounding-limb.

Type in collection of Mr. H. J. Finlay.

Height, 38 mm.; diameter, 35 mm.

Localities.- Boulder Hill; Wangaloa; ? Hampden (a crushed specimen in which the outer lip is slightly retracted to the suture and which may be a distinct species).

Because of its low spire, this shell somewhat resembles *N. suteri*, but several important characters show that it is but distantly related thereto. These are the sinuous inner margin of the aperture, impressed suture, absence of any trace of a funicle or circum-umbilical limb, and strongly antecurrent outer lip. The salient characters are reminiscent of Hedley's genus *Friginatica*, members of which are all very small, and with rather elevated spires, but with a sunken suture, and "without an umbilical funicle or a callus pad at the insertion of the right lip."

Uber (Euspira) firmus n. sp. (Plate 59, figs. 2, 3.)

Shell of moderate size, globose-ovate, solid; spire one-half the height of aperture or less; whorls about 5, convex on spire, body-whorl globular; suture abutting, sometimes tangential; aperture semilunar; outer lip straight, retracted to suture, inclined about 35° from vertical; inner lip slightly concave, with thin parietal callus contracting suddenly to inner margin; umbilicus moderate to fairly large, open, without funicle.

Type in collection of Mr. H. J. Finlay.

Height, 24 mm.; diameter, 21 mm.

Localities.—Boulder Hill (type); 887A, Wangaloa (= *P. amphialis* of Suter, 1921, p. 97); 480, "Island sandstone," overlying coal-beds, Waihao River (= *P. huttoni* and *P. amphialis* of Suter, 1921, p. 65).

Uber (Euspira) lateapertus n. sp. (Plate 59, figs. 4, 5, 6.)

Shell of moderate size, globose; spire gradate, about one-third the height of aperture; whorls 5, convex on spire; suture deeply impressed,

channelled in young; aperture ovate; outer lip slightly sinuous, retracted to suture for very short distance; inner lip thin, almost straight with very thin callus on parietal wall; umbilicus very large, widely open, the earlier whorls visible, apertural wall of umbilicus closely spirally grooved.

Type in collection of Mr. H. J. Finlay.

Height, 18 mm.; diameter, 17 mm.

Locality.—Boulder Hill

Uber (Euspira) pukeuriensis n. sp. (Plate 55, fig. 20.)

Shell very small; spire scalar, over one-half height of aperture; whorls 3½; suture slightly impressed; aperture oval; outer lip straight, antecurrent to suture, inclined at about 25° from vertical; inner lip thin, not reflexed; umbilicus widely open, without funicle and free from apertural callus.

Holotype in collection of Mr. H. J. Finlay.

Height, 6 mm.; diameter, 5·5 mm.

Localities.—Pukeuri, Oamaru (type); shell-bed, Target Gully, Oamaru.

Remarks.—Nearest to *U. barrierensis*, but differs in having an impressed suture.

Uber (Euspira) pseudovitreus (Finlay). (Plate 55, fig. 21.)

1924. *Polinices pseudovitreus* Finlay, *Trans. N.Z. Inst.*, vol. 55, p. 452, pl. 49, figs. 3a, 3b, 3c, 3d.

Type in collection of Mr. H. J. Finlay.

Height, 8 mm.; diameter, 7 mm.

Localities.—Rifle Butts, Oamaru (type); 1160, Awamoa Creek.

Remarks.—Typically this shell has a high, rather clumsy spire, but in some cases it is low. The single Awamoan specimen belongs to the low-spired form.

Uber (Euspira) vitreus (Hutton). (Plate 55, fig. 19.)

1873. *Natica vitrea* Hutton, *Cat. Mar. Moll.*, p. 21.
1880. *Lunatia vitrea*, *Manual N.Z. Moll.*, p. 72.
1913. *Polinices amphialus* Watson: Suter, *Manual N.Z. Moll.*, p. 290, pl. 46, fig. 1.
1915. *Polinices vitreus* Hutton: Iredale, *Trans. N.Z. Inst.*, vol. 47, p. 456.

Lectotype in Dominion Museum.

Height, 8 mm.; diameter, 7 mm.

Locality.—Stewart Island (Recent).

Although this seems to be a fairly common shell in Recent times, not one fossil specimen has been seen during this revision. Suter's identifications of fossil, and even Recent, species are quite inconsistent and unreliable.

Hutton (1884, p. 934) thought his species was the same as the later *U. amphialus* (Watson), but neither Watson nor Iredale agreed with this identification. Iredale further pointed out that *U. vitreus* is the older name, and that Suter's use of *U. amphialus* was therefore wrong. Watson (1886, p. 438) says of his species, "combines a flattened globose form with a prominent pointed base and small raised scalar spire in a way that is very peculiar—so much so, indeed, that it almost recalls an *Amphibola*." This description does not suit *U. vitreus* at all, so the two species must be regarded as distinct.

The striking feature of *U. vitreus* is the circular section of the umbilicus when viewed from the base. The inner margin of the aperture does not cut the circle as in other small shells which have been mistaken for this species. Also, the outer lip is retracted to the suture.

Hutton's type material consists of two specimens, the larger of which has been selected as lectotype (see Plate 55, fig. 19). As is often the case, Hutton's measurements (0·35 in. × 0·34 in.) are larger than those of either of his "types." Specimens up to 11 mm. in height are in the Dominion Museum.

Uber (Euspira) barrierensis n. sp. (Plate 55, fig. 15.)

Shell very small, broadly oval, vitreous; spire low; whorls 3½; protoconch smooth, nucleus moderate, whorls polished with microscopic spirals and fine growth-lines; suture abutting; aperture ovate; outer lip almost straight, antecurrent to suture, inclined about 30° from vertical; inner margin thin, slightly reflexed on parietal wall; umbilicus widely open, without funicle and not invaded by callus, traversed on apertural wall by faint spiral threads; operculum unknown.

Holotype and paratypes in the Suter collection, Wanganui Museum.

Height, 5 mm.; diameter, 5 mm.

Locality.—Off Great Barrier Island (110 fathoms).

Remarks.—This shell is referred to by Suter (1913, p. 289) in his remarks on *N. australis*. The identification label was afterwards altered by him to "*Polinices amphialus*." Of the four specimens none shows any colour, so the specimens with "radiate brown bands" must have been removed.

U. barrierensis differs from *U. vitreus* in its depressed shape and very wide umbilicus.

b. Subgenus NEVERITA Risso, 1826.

Shell of moderate size, depressed; aperture semilunar; outer lip greatly inclined from vertical (40° – 45°); umbilicus with an enormous funicle often quite filling it, and coalescing with the parietal callus.

Type: *N. josephinia* Risso.

Distinguished from *Uber* by the much greater obliquity of the aperture combined with the large size of the funicle.

Uber (Neverita) pontis n. sp. (Plate 57, figs. 15, 16, 17.)

Shell small; spire relatively high; whorls convex, body-whorl depressed near suture; outer lip very much inclined to axis of shell; umbilicus almost filled by large funicle which is overlapped by parietal callus, leaving, however, a small umbilical opening. The callus is wider at anterior end and tapers posteriorly, but expands somewhat again just before it joins outer lip.

Holotype in Dominion Museum, Wellington.

Height, 10 mm.; diameter, 10 mm.

Locality.—Greensands, McCullough's Bridge, Waihao River (J. A. Thomson).

In typical *Neverita* the umbilicus is completely filled by funicle and callus, but although there is a small umbilical opening in this shell the great obliquity of the outer lip and the general appearance indicate close relationship to this subgenus. This is the only specimen of *Neverita* seen in the New Zealand material examined.

4. Genus Sinum Bolten, 1798.

a. Subgenus Sinum s. str. (= *Sigaretus* Lamarck, 1799).

"Shell depressed, auriform, spirally striated or furrowed. Spire very low with rapidly widening whorls. Aperture greatly distended; operculum horny."—(Zittel.)

Type: *Helix haliotoidea* Linné.

Sinum fornicatum Suter. (Plate 60, figs. 4, 9.)

1917. *Sinum fornicatum* Suter, *N.Z. Geol. Surv. Pal. Bull.* 5, p. 11, pl. 3, fig. 5.

Localities.—Maerewhenua River, right bank (Uttley, 1920, p. 150); 480, "Island sandstone," Waihao River; ? 176, Black Point, Waitaki Valley.

This shell is more elevated than the typical *Sinum* with its extremely flattened body-whorl and greatly inclined convex outer lip. The umbilicus also is fairly open, only one side being covered by the reflexed inner lip; but it is nearer to *Sinum* s. str. than to *Eunaticina.* The Black Point specimen is more inflated than the others, and may be a separate species. Occurrences of this genus are very rare in New Zealand, the three localities mentioned being represented each, as far as the writer knows, by only one specimen. The uniformly low horizon is noteworthy: in all cases these fossils occur in the basal marine sandstones just above the coal-measures.

Sinum infirmum n. sp. (Plate 60, figs. 7, 8.)

Shell very small, fragile, depressed auriform, of about three and a half whorls, of which the smooth protoconch occupies over two and a half; spire flat; surface of body-whorl with fine slightly undulating spiral grooves crossed by convex growth-lines; aperture oval, oblique, greatly dilated; outer lip strongly convex; inner lip broken away; umbilicus open but small.

Holotype in collection of Mr. H. J. Finlay.

Height, 2 mm.; diameter, 3·5 mm.

Localities.—Ardgowan (type); Pukeuri.

The type is a juvenile; a fragment from Ardgowan is from a shell that was about 10 mm. in diameter when complete.

S. infirmum can be distinguished from *S. fornicatum* not only by its smaller size, but also by its much flatter spire.

b. Subgenus Eunaticina Fischer, 1885.

Shell longitudinally oval, spirally striated, umbilicated; body-whorl flattened; aperture distended; outer lip convex, moderately inclined; columella with a bulge opposite the umbilicus.

Type: *N. papilla* Gmelin.

Sinum (Eunaticina) cinctum (Hutton). (Plate 60, figs. 12, 16.)

1885. *Sigaretus (Naticina) cinctus* Hutton, *Trans. N.Z. Inst.*, vol. 17, p. 318, pl. 18, fig. 12.

1893. *Sigaretus cinctus* Hutton, *Macleay Mem. Vol.*, p. 55.

1915. *Polinices (Euspira) cinctus* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull. 3*, p. 9, pl. 4, fig. 5.

1918. *Sinum cinctum* (Hutton): Suter, *Alph. List N.Z. Tert. Moll.*, p. 25.

Although this specific name appears in many lists of New Zealand Mollusca, none of the specimens examined by the writer was correctly

identified. Hutton says that the type came from "Wanganui," having been sent down by Mr. Drew; but, although many collections have been made at this locality since that time, no one has found another specimen. Both the late Mr. R. Murdoch and Dr. Marshall agreed that they had never seen a similar shell in all their material. The reddish-brown staining on the type is not quite the same as that of any specimens the writer has seen from Wanganui.

The shell is a typical *Eunaticina*, and as this is the only New Zealand specimen of the subgenus which has been seen it should not be unreservedly admitted as a member of our fauna. There is no direct proof that the shell is a foreign one which became mixed with New Zealand specimens; but such things did happen to Hutton (*e.g.*, *Trigonia semiundulata, Raeta perspicua, Chione lamellata*, &c.), so that care must be taken in accepting doubtful species.

5. Genus GLOBISINUM n. gen.

Shell large, globose, thin; spire low; whorls convex, spirally striated; protoconch of two and a half whorls sharply defined from the neanic shell, smooth and polished except for the last quarter-turn where the spirals are foreshadowed; suture abutting; aperture large, ovate; outer lip thin, straight or slightly convex, scarcely retracted to suture, inclined at about 25° from the vertical; inner lip strongly sinuous with thin varnish on parietal wall; umbilicus variable, sometimes absent, when present partly overlain by thin inner lip; in the genotype there is no umbilicus.

Type: *Sigaretus drewi* Murdoch.

Differs from *Sinum* s. str. in its globular shape, sinuous columella, and much less inclined lip. The shape is also different from *Eunaticina*, which is longitudinally oval and has a flattened body, a more distended aperture, and a different curve to the inner lip.

Sigaretotrema Sacco, 1890, approaches *Globisinum* in shape, though the body-whorl is still slightly flattened, the outer lip is more inclined, and the inner lip is almost straight.

Under the genus *Sinum* Bolten, Suter (1917, p. 88) lists the following species: *Sinum carinatum* (Hutton), *S. fornicatum* Suter, *S.* (*Eunaticina*) *cinctum* (Hutton), *S.* (*Eunaticina*) *drewi* (Murdoch), *S.* (*Eunaticina*) *elegans* Suter, *S.* (*Eunaticina*) *miocaenicum* (Suter), *S.* (*Eunaticina*) *undulatum* (Hutton). *S. carinatum* is a peculiar keeled shell here located under *Micreschara* (*Macromphalina*); *S. fornicatum* is a *Sinum*, and *S. cinctum* is a typical *Eunaticina*. The other species, however, do not agree with *Eunaticina*, and form a well-defined group, to which should be added *Ampullina spiralis* Marshall from the Wangaloa beds.

The generic position of these shells has been a source of considerable trouble. Hutton at first attributed them to *Sigaretus* Lamarck (= *Sinum* Bolten), but later to *Ampullina*. *Sigaretus* was also used by Murdoch (1899, p. 320). In a footnote to the latter's specific description, the editor of the *Proceedings of the Malacological Society* says, "In attributing this shell to the genus *Sigaretus* the author has evidently followed Hutton, and, owing to the impossibility of communicating with him in time for publication, we have left it so, merely adding a '?'; but it is evidently nearer to *Ampullina*."

The generic position under *Ampullina* was therefore used by Suter (1913, 1914, 1915) and by Marshall (1917), but was changed back to *Sinum*

(= *Sigaretus*), apparently on Cossmann's recommendation (Suter, 1917, p. 88), because there was no umbilical limb. Neither genus is, however, satisfactory for these shells. They differ from *Ampullina*, as was pointed out by Cossmann, in having no basal limb, and in being conspicuously spirally striated; while they are equally far apart from *Sinum* because of their totally different shape, not having the greatly flattened body, as is shown by their being mistaken for *Ampullina*. The subgenus *Eunaticina* (type, *N. papilla* Gmelin), in which Suter placed them, has a sinuous inner lip, but there is a bulge over the umbilicus which is not present in *Globisinum*; the shape also is quite different. In his review of *New Zealand Geological Survey Palaeontological Bulletin 5*, concerning *Sinum* (*Eunaticina*) *elegans*, Cossmann (1918, p. 24) says, "La determination generique me paraît bien douteuse."

Taking all these things into consideration, it is clear that a new generic division is required; the name *Globisinum* is therefore proposed, with *Sigaretus drewi* Murdoch as type. The Wangaloan species has a restricted umbilicus, while in *G. elegans* from Waihao greensand the shell is more loosely coiled, so that the umbilicus is wider In the Awamoan species there is a tightening of the coil and a consequent restriction of the umbilicus; this process is carried still further in the Wanganuian *G. undulatum* and *G. drewi*, for here the basal perforation is obliterated. Apart from this umbilical variation there is little difference between the earliest and the latest species, and the simple globular shape indicates a more primitive type of shell than *Sinum* or *Eunaticina*. *Globisinum* has existed in the New Zealand area at least since the dawn of the Tertiary, and seems to have been represented in Australia by *Natica arata* Tate, from the Lower Tertiary of River Murray cliffs. The genus may, indeed, extend back to the Cretaceous, for the small *Natica ingrata* Wilckens (1922, p. 7) perhaps belongs to that period. It has the same shape, and some specimens show spirals on the base (see Trechmann, 1917, pl. 19, fig. 9*b*).

Ampullina striata Gabb (1869 p. 161, pl. 27. fig. 40) from the Martinez beds appears to be an imperforate species of the genus. There is a considerable resemblance in form between these shells and *Vanikoro* Q. & G., but, the animal and operculum being unknown, they had best be retained under the subfamily Naticinae.

Key to Species.

spirale: umbilicus very narrow, aperture rather small, spire relatively high.
elegans: umbilicus large; sculpture fine, coarser on lower half.
miocaenicum: umbilicus rather small, partly covered by reflexed inner lip.
drewi: very large, no umbilicus; spire moderate, columella almost straight.
undulatum: moderate size, no umbilicus; spire low, columella concave, aperture somewhat dilated.
venustum: very large, no umbilicus; spire rather high, columella concave.

Globisinum elegans (Suter). (Plate 60, fig. 18.)

1917. *Sinum* (*Eunaticina*) *elegans* Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 11, pl. 3, fig. 4.

Suter gives as locality of the type, "630, Teaneraki (= Enfield), near Oamaru, North Otago, T. Esdaile." This collection is an unreliable one, containing Hawke's Bay and Mount Harris specimens, and is wrongly attributed to Mr. Esdaile. Most of the specimens, including the type of *G. elegans*, are probably from McCullough's Bridge, Waihao River, where the species is not uncommon. The aperture of the type is broken away

for a considerable distance, and the line of the suture can be followed to the middle of the whorl on Suter's figure, which therefore gives an impression of too great height in comparison with the width. The spirals are generally, but not always, much stronger on the lower part of the whorl than on the upper.

Globisinum spirale (Marshall). (Plate 60, fig. 17.)

1917. *Ampullina spiralis* Marshall, *Trans. N.Z. Inst.*, vol. 49, p. 452, pl. 34, fig. 17.

Localities.—Wangaloa (type); Boulder Hill.
This is the "*Eudolium?*" of Suter (1921, p. 96).

Globisinum miocaenicum (Suter). (Plate 60, fig. 13.)

1873. *Sigaretus subglobosus* Sowerby: Hutton, *Cat. Tert. Moll.*, p. 9 (not of Sowb.).
1914. *Ampullina miocaenica* Suter, *N.Z. Geol. Surv. Pal. Bull. 2*, p. 21, pl. 2, fig. 2.
1918. *Sinum miocaenicum* (Suter), *Alph. List N.Z. Tert. Moll.*, p. 25.

Localities.—Awamoa (type); Pukeuri, near Oamaru; 166, 458, Pareora; 475, Mount Harris, South Canterbury; 950, Parson's Creek, Oamaru (= *Sinum cinctum* of Suter, 1921, p. 80); 125, Fox River, Brighton (= *Sinum cinctum* of Suter, 1921, p. 40); Trig. 2, Otekaike, Otiake beds above limestone.

Of the specimens identified as *G. miocaenicum* from "tuffs interbedded with chalk marls, Coleridge Creek, Trelissick Basin" (Suter, 1921, p. 51), only one is in a good condition. It is certainly very like *G. miocaenicum*, but differs slightly in several ways. The body-whorl is even more globose than that of *G. miocaenicum*, so that the distance from the umbilicus to the base of the shell is very short, thus causing the spirals to abut on the lower part of the inner lip at a high angle. The umbilicus is slightly wider than in the Awamoan species. More specimens, however, are required to show whether these differences are constant and worth specific recognition. It is possible that the relationship is closer to *G. spirale*, which has a higher spire and shorter anterior development than *G. miocaenicum*.

Globisinum undulatum (Hutton). (Plate 60, fig. 14.)

1885. *Sigaretus undulatus* Hutton, *Trans. N.Z. Inst*, vol. 17, p. 318, pl. 18, fig. 11.
1885. *Natica (Ampullina) laevis* Hutton, *Trans. N.Z. Inst.*, vol. 17, p. 317, pl. 18, fig. 10.
1893. *Sigaretus undulatus* Hutton, *Macleay Mem. Vol.*, p. 55, pl. 7, fig. 41.
1893. *Natica laevis* Hutton, *Macleay Mem. Vol.*, p. 54, pl. 7, fig. 39.
1913. *Ampullina undulata* (Hutton): Suter, *Man. N.Z. Moll.*, p. 291, pl. 15, fig. 17.
1915. *Ampullina undulata* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull. 3*, p. 11.
1915. *Polinices laevis* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull. 3*, p. 10.
1917. *Sinum undulatum* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 88.

The type of this species is a Wanganui fossil (precise horizon unknown), and the only record of its Recent occurrence is by Webster (1905, p. 280), who collected a specimen at Cape Maria van Diemen. It is possible that his shell was a *G. venustum*. Hutton's two syntypes of *Natica laevis* are identical in every respect with *G. undulatum* except that the spiral ornamentation is lacking. A careful scrutiny of the surface shows that it is much pitted, and that there are traces of the spirals in protected areas. It is therefore practically certain that the sculpture has been worn off by attrition in the shell-bed from which the specimens came.

Type from Wanganui, but horizon uncertain.

Localities.—Recent (only one record); Castlecliff, Wanganui (type?); Nukumaru (*fide* Marshall and Murdoch); Petane; 1063, shell-bed below Petane limestone, Okawa Creek, Ngaruroro River.

Globisinum drewi (Murdoch). (Plate 60, figs. 11, 15.)

1899. *Sigaretus* (?) *drewi* Murdoch, *Proc. Malac. Soc.*, vol. 3, p. 320, pl. 16, fig. 1.
1915. *Ampullina drewi* (Murdoch): Suter, *Alph. Hand-list N.Z. Tert. Moll.*, p. 3.
1917. *Sinum* (*Eunaticina*) *drewi* (Murdoch): Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 88.

A careful examination of the anterior part of the body-whorl of the type shows faint indications of low spiral ridges such as exist on the type of *G. venustum*, but smaller specimens from Kai Iwi show no sign of them.

Holotype in Wanganui Museum.

Height, 38 mm.; diameter, 37 mm.

Locality.—Coast north-west of Wanganui, probably in the vicinity of Kai Iwi.

Globisinum venustum (Suter). (Plate 60, fig. 10.)

1907. *Euspira venusta* Suter, *Proc. Mal. Soc.*, vol. 7, No. 4, pl. 18, fig. 13.
1913. *Ampullina venusta* (Suter), *Manual N.Z. Moll.*, p. 292, pl. 15, fig. 18.

Suter's figure is misleading, for it gives far too great prominence to the spiral ribs on the lower part of the shell. These are so inconspicuous that they make practically no difference to the profile, and even when the light is in a favourable position thay can hardly be seen. A topotype in the possession of Miss M. K. Mestayer does not show the ribs at all, and has much the appearance of *G. drewi*. These are the only two specimens of the species which have been found; and, since complete adult specimens of both *G. undulatum and G. drewi* are rare, the material available is not sufficient to give a proper idea of the relative values of the three species named. They may not all be worth recognition.

Holotype in the Suter collection, Wanganui Museum.

Height, 40 mm.; diameter, 37 mm.

Locality.—Near Cape Farewell. (Recent.)

6. Genus Amouropsella Chelot, 1885.

"Shell thin, scalariform, with elevated spire, sharp at the top; whorls numerous, generally rendered gradate by a spiral plane, sometimes even keeled; aperture scarcely more than half the total height, effuse in front; umbilicus rather small, from the depths of which issues a narrow and sharp ridge which quickly joins the keeled margin of the effuse portion of the aperture, lip little inclined, straight, a little antecurrent opposite the flattened plane, columella scarcely excavated, outer margin little calloused and reflected on the umbilicus."—(Cossmann.)

Genotype: *Natica spirata* Lamk. (Eocene.)

Cossmann (1919, p. 454) places *Amauropsella* Chelot, 1885, as a section of *Crommium* Cossmann, 1888, an interpretation of the law of priority which is not generally favoured. The New Zealand species differ in having a channelled suture, and *A. major* in having spiral grooves. *Amauropsina* has a channelled suture, but the umbilical ridge is not so well marked and is farther forward. *Amauropsella* ranges from Palaeocene to Aquitanian in Europe.

Amauropsella major (Marshall). (Plate 60, fig. 19.)

1917. *Nucleopsis major* Marshall, *Trans. N.Z. Inst.*, vol. 49, p. 458, pl. 36, fig. 38.

Shell rather small, ovate; spire gradate, two-thirds the height of aperture; whorls 6, convex on spire and narrowly shouldered where they bend to the well-channelled suture; surface with numerous spiral threads separated by narrow grooves, about ten on the penultimate and thirty on the body, the upper ones rather broad and often divided by a secondary groove; aperture ovate, effuse below; outer lip slightly concave and gently retracted to the suture in large specimens (but these features are not clear in the type), inclined about 15° from vertical; inner lip nearly straight, with a thin enamel on parietal wall; umbilicus narrow, with sharp spiral ridge descending to meet anterior part of inner margin where it starts to become effuse.

Type in Otago Museum.

Height, 10 mm.; diameter, 6·5 mm.

Localities.—Wangaloa; Boulder Hill.

The original description does not mention the umbilical ridge, nor is it shown in the figure. It is, however, quite well developed. The inclined aperture, the ridged umbilicus, and the smooth columella show that the shell is not one of the Acteonidae.

The strong spiral sculpture is an unusual character for the group, but that it is not of generic importance is indicated by the presence of a smooth shell with the same essential features in the same beds.

Amauropsis martinezensis Dickerson (1914, p. 142, p. 13, figs. 4 *a*, *b*) has a "surface marked by fine but well-marked revolving lines."

Amauropsella teres n. sp. (Plate 60, fig. 20.)

Shell rather small, ovate; spire gradate, two-thirds the height of aperture; whorls 6, convex on spire and narrowly shouldered where they bend over to the well-channelled suture, surface with growth-lines only; aperture ovate, effuse below; outer lip very slightly concave and almost imperceptibly retracted to suture; inner lip straight, with only thin enamel on parietal wall; umbilicus rather small, but not invaded by callus, with sharp spiral ridge which abuts against a projection at anterior end of inner margin.

Type in collection of Mr. H. J. Finlay.

Height, 14 mm.; diameter, 11 mm.

Locality.—Boulder Hill.

II. Family NARICIDAE.

Genus MICRESCHARA Cossmann, 1881.

Section MACROMPALINA Cossmann, 1888.

"Shell auriform, very widely umbilicated, feebly trelissed, aperture obliquely spread out and very depressed, walls of umbilicus ornamented with radial and lamellar folds from peripheral keel.

"Type: *Sigaretus problematicus* Desh. (Eocene.)

"This section—which is separated from *Micreschara* s. str. by its auriform shape and by its wide umbilical funnel—is not confined to the Eocene, as was thought until now; not only did it live in the Miocene of

the South-west, but it is also represented in the Tortonian of Hungary."—(Cossmann.)

The appearance of this rare subgenus in New Zealand is of great interest, especially since its time-range here corresponds approximately to that in Europe.

KEY TO SPECIES.

auriformis: circum-umbilical keel set in from the rounded periphery.
huttoni: circum-umbilical keel forming the periphery.

Micreschara (Macromphalina) auriformis n. sp. (Plate 60, figs. 5, 6.)

Shell small, auriform, depressed; spire very low; whorls 3 or 4 rapidly increasing; surface smooth; suture plain, tangential at first, but abutting near aperture, which is oval, distended, and much inclined; outer lip convex, retracted to suture; inner lip concave, straightened below, slightly reflexed; umbilicus very wide, joining base of body-whorl at sharp angle some distance in from rounded periphery.

Type in collection of Mr. H. J. Finlay.

Height, 3·5 mm.; diameter, 5 mm.

Locality.—Boulder Hill (Palaeocene).

Micreschara (Macromphalina) huttoni n. mut. (Plate 60, figs. 1, 2, 3.)

1877. *Sigaretus carinatus* Hutton, *Trans. N.Z. Inst.*, vol. 9, p. 597 (not of Muenster nor Goldfuss).
1914. *Ampullina carinata* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull. 2*, p. 10, pl. 8, figs. 2 *a*, *b*, *c*.
1918. *Sinum carinatum* (Hutton): Suter, *N.Z. Geol. Surv. Pal. Bull. 5*, p. 88.

Localities.—White Rock River, Pareora (type); Target Gully, Oamaru (*fide* P. Marshall). (Lower Miocene or Upper Oligocene.)

M. problematica Desh. and *M. decussata* Cossm. from the Eocene of the Paris Basin are closely similar to the New Zealand species.

The combination *Sigaretus carinatus* was preoccupied when Hutton proposed it—by A. Goldfuss, 1837 (*Abbild. u. Beschr. d. Petrefakten Deutchlands, &c.*, iii, 13, t. 168, f. 16), and by Muenster, 1842 (*Beitrage zur Petrefakten-Kunde*, iv, 93, t. 9, f. 16): therefore the specific name *huttoni* is proposed.

SYNOPSIS OF CHANGES IN NOMENCLATURE AND CLASSIFICATION.

Suter's Classification.	Revised Classification.
Natica australis (Hutton) ..	.. *Natica maoria* Finlay.
—— *zelandica* Q. & G. ..	.. —— *zelandica* Q. & G.
Polinices ambiguus Suter ..	.. (Not seen).*
—— *amphialus* (Watson) ..	.. *Uber* (*Euspira*) *vitreus* (Hutton).
—— *callosus* (Hutton) ..	.. —— *intracrassus* (Finlay).
—— *gibbosus* (Hutton) ..	} —— *huttoni* Ihering.
—— (*Neverita*) *huttoni* Ihering	} —— *huttoni* Ihering.
—— *laevis* (Hutton) ..	.. *Globisinum undulatum* (Hutton).
—— (*Euspira*) *ovatus* (Hutton)	.. *Uber ovuloides* n. sp.
—— *planispirus* Suter ..	.. *Natica* (*Magnatica*) *suteri* n. mut.
—— (*Neverita*) *sagenus* Suter	.. *Uber sagenus* Suter.
Sinum carinatum (Hutton)	.. *Micreschara* (*Macromphalina*) *huttoni* n. mut.

* The type could not be found in Canterbury Museum.

Suter's Classification.	Revised Classification.
Sinum (*Eunaticina*) *cinctum* (Hutton)	*Sinum* (*Eunaticina*) *cinctum* (Hutton) (? New Zealand).
—— (*Eunaticina*) *drewi* (Murdoch) ..	*Globisinum drewi* (Murdoch).
—— (*Eunaticina elegans* Suter ..	—— *elegans* (Suter).
—— *fornicatum* Suter	*Sinum fornicatum* Suter.
—— (*Eunaticina*) *miocaenicum* Suter	*Globisinum miocaenicum* (Suter).
—— (*Eunaticina*) *undulatum* (Hutton)	—— *undulatum* (Hutton).
Ampullina (*Megatylotus*) *suturalis* (Hutton)	*Sulconacca suturalis* (Hutton).
—— *waihaoensis* Suter	*Natica* (*Carinacca*) *waihaoensis* (Suter).
—— *venusta* Suter	*Globisinum venustum* (Suter).
Nucleopsis major Marshall.. ..	*Amauropsella major* (Marshall).
Turbo approximatus (Suter) ..	*Natica* (*Magnatica*) *approximata* (Suter).

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The Post-Tertiary History of New Zealand.

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[*Read, with the permission of the Director of the New Zealand Geological Survey, before the Wellington Philosophical Society, 10th October, 1923; received by Editor, 22nd December, 1923; issued separately, 28th August, 1924.*]

Throughout the geological literature of New Zealand are numerous references to changes in the height of the land in respect to sea-level within Recent and post-Tertiary times. At many points on the coast features definitely associated with the sea or its edge are inland and above the strand; at other and perhaps adjacent points there is equally definite evidence of considerable depression. The object of this paper is to bring together, and as far as possible to correlate, the known pertinent facts, and to endeavour to outline the sequence of the oscillations. The evidence suggests that New Zealand has changed its level in respect to the sea as a unit, either on account of the retreat of the ocean or by uplift of the whole archipelago. There may have been some local tiltings and differential warpings, but these appear to have been unimportant if compared with the widespread epeirogenic oscillations that have affected the Islands.

In New Zealand the Tertiary closed with a long-continued series of movements by which groups of earth-blocks were uplifted to form mountain-ranges, while adjacent blocks were relatively depressed in trough-like basins. The mountains have since been much carved by ice and water, and the great tectonic valleys in part filled in by the rivers and the sea, but the broad outlines of New Zealand as it now is were created at this period. The land was at one time 1,000 ft. or more higher than it now is, but later was depressed till the old strand-line was submerged to 1,000 ft. or more below its present level. The deposits formed prior to and during this depression are here considered of early Pleistocene, and those of the succeeding elevation of younger Pleistocene age. The former deposits are represented by volcanic accumulations and by beds of glacial, fluviatile, estuarine, and littoral origin. The younger Pleistocene beds are chiefly high-level terraces bordering river-valleys, and littoral deposits forming coastal platforms or veneering wave-cut benches. The general elevatory movement was continued till the land was several hundred feet higher than at present. It was succeeded by depression that raised the strand-line about 120 ft. above that of to-day. The last considerable movement has been one of uplift to the present position. The deposits of the last-mentioned depression and subsequent elevation form the bulk of the Recent deposits of New Zealand.

This paper deals chiefly with the evidences of uplift and subsidence that have been observed in coastal districts. No account is given of the plains and river-valleys of New Zealand, though these have been profoundly modified and in part created by the movements. The effects of glaciation are not discussed, nor do the deposits of early and middle Pleistocene age receive more than mention.

General Considerations.

After long-continued standstill there will be formed around any sea-girt land a gently-sloping submarine shelf, which consists of a wave-cut platform, of such a platform veneered with loose deposits, or of loose deposits

entirely. The new shore-line produced by elevation will soon be modified. In some localities it will be cut back by the waves, in others it will be prograded, and between the points of maximum sea-advance and maximum sea-retreat will be innumerable gradations.

The under-water slope of a prograded shore is likely to be continued above sea-level by slope, fan, or deltaic deposits with little or no change of grade. After elevation, unless there is considerable difference in the nature of the terrestrial and marine deposits, the old strand-line will probably soon be obliterated. The summit and basal edges of sea-cliffs cut by the waves during a period of comparative rest are much more decided lines of demarcation. The summit edges, except on coasts where the controlling conditions are far more uniform than in New Zealand, are not likely to be horizontal even if the uplift is horizontal. The base of an old sea-cliff—that is, the inner edge of a coastal terrace—will probably furnish much more reliable information as to the nature and amount of movement of the strand-line; but, as explained by Darwin in the second chapter of his *Geological Observation on South America*, it by no means follows that the inner edge of a coastal bench on a horizontally uplifted shore is horizontal. "With respect to the basal or lower edges of the escarpments, from picturing in one's mind ancient bays *entirely* surrounded at successive periods by cliff-formed shores, one's first impression is that they at least necessarily must be horizontal, if the elevation has been horizontal. But here is a fallacy: for after the sea has, during a cessation of the elevation, worn cliffs all round the shores of a bay, when the movement recommences, and especially if it recommences slowly, it might well happen that, at the exposed mouth of the bay, the waves might continue for some time wearing into the land, whilst in the protected and upper parts successive beach-lines might be accumulating in a sloping surface or terrace at the foot of the cliffs which had been lately reached: hence, supposing the whole line of escarpment to be finally uplifted above the reach of the sea, its basal line or foot near the mouth will run at a lower level than in the upper or protected parts of the bay: consequently this basal line will not be horizontal." This explanation has evidently a wider application than Darwin gave it. The base of any sea-cliff that, during gradual horizontal uplift, is unequally cut back by the waves, either by reason of unequal hardness of the rock or unequal protection from wave-attack afforded by promontories or coastal drift, will not be horizontal. And the New Zealand coast is formed of rocks so differing in hardness within short distances, and is so irregular in outline, that caution is necessary in interpreting the evidence afforded by the inner edge of a coastal terrace. Moreover, the base of a sea-cliff after uplift is peculiarly liable to be obscured by talus, alluvial, and dune deposits. Notwithstanding these defects the inner edges of raised shore-platforms furnish the most reliable information regarding land-uplift, and, provided observations are sufficiently widespread to eliminate local peculiarities, the evidence may be confidently accepted.

Darwin in the work already quoted discussed the nature of the uplift between the periods of comparative rest or slight depression when the sea-cliffs were formed. He concluded from the uniformity in size of the pebbles over the whole surface of platforms miles in width, and from the fact that the shells strewing the benches were all of littoral species, that the uplift had been by small sudden starts such as those accompanying recent earthquakes, or, more probably, by such starts conjointly with a gradual upward movement, and had not been due to great and sudden upheavals. In New Zealand the irregular coast-line causes the beach deposits to vary greatly

in short distances, and shells are rarely found on the coastal terraces. But the series of low raised beaches at Miramar (61, p. 316), Gisborne (52, p. 23, and 80, p. 533), and Tolaga Bay (52, p. 23), together with the fairly uniform distribution of blacksand on the raised beaches of the west coast of the South Island, suggest the uplift in New Zealand took place in a manner similar to that of South America.

If the elevation of the land is fairly uniform, though interrupted by periods of rest or slight depression, there will be places, on a coast so diversified as that of New Zealand, where the emerging wave-formed shelf will be (1) prograded, (2) unaltered, (3) partially destroyed, and (4) wholly destroyed. In the first case the surface of the coastal terrace will be fairly uniform, with a grade flatter than that of the foreshore; in the second case the grade will be the same throughout; in the third case the raised platform will be cut into a series of steps which may occur as decided breaks, or be so small that the whole surface may approximate a sloping plane with a grade steeper than that of the under-water surface; in the fourth case the attack of the waves may be strong enough to advance the strand landward past the old shore-line. All these types of shore may be represented on a short stretch of coast, each type grading into that adjacent to it. Again, because one part of the coast was prograded at one particular contour it does not follow that it was prograded at another contour, for elevation may bring to the surface of the sea promontories and islands of hard rock which may protect and cause to be prograded parts of the coast that at other contours were retrograded. Again, a slight depression may cause a stream to change its course owing to alluviation, and its discharge by another outlet may alter locally the distribution of the coastal drift. Hence, though the whole coast may have been uniformly subjected to a series of oscillations, the full history of the oscillations may not be decipherable in any one area, and different chapters of the history must be read in different districts.

Evidence of Elevation.

North Auckland Peninsula.

The evidences of elevation will first be considered, and, in order that the facts may be conveniently presented, the coast of each Island is divided into four portions. S. Percy Smith (72, pp. 403–10: see also 33, p. 157; 35, p. 11; 40, p. 4; and 43, p. 30) noted the occurrence of raised beaches about 15 ft. above sea-level at many points on the east and west coasts of the North Auckland Peninsula. McKay (25, p. 77) observed beaches and mud-flats at a similar height in the extreme north of North Zealand, and Hochstetter (111, p. 266) and Hutton (63, p. 161) remarked on the slight elevation that has taken place at Manukau North Head. Smith (72, p. 409), without mentioning precise localities, has stated that a bench about 100 ft. above sea-level occurs at several points near Auckland and Kaipara. At Onerahi, in Whangarei Inlet, there is a platform about 60 ft. high, and the Town of Whangarei, at the head of the harbour, is built in part on a 10–15 ft. raised beach and in part on a terrace about 50 ft. high that rises inland along the continuing valley.

Other base levels of erosion have not been definitely recognized in North Auckland, but several facts of physiography noted by various writers have significance if considered in this connection. Thus McKay (25, p. 71) wrote: "Whangape Harbour is bounded on the south and west by heights . . . which, from an elevation of 1,000 ft. to 1,500 ft., slope

gradually to half that height on the coast-line." And again: "Towards the east [of Parengarenga Harbour] there is a tendency to form tablelands 400 ft. to 600 ft. above sea-level." Bell and Clarke (87, p. 614) suggest that a tableland about 1,000 ft. high that occupies a relatively considerable area in the extreme north of New Zealand is the remnant of a peneplain. Lignitic bands occur in the cliffs of Pleistocene sands that back the low raised beaches along the west coast between Kaipara Harbour and Maunganui Bluff (79, p. 565). These are evidence of elevation, but of what amount is unknown.

Auckland to East Cape.

Smith (72, pp. 403 and 407) has also traced the 15 ft. raised beach at various points in the Hauraki Gulf and Bay of Plenty. Hutton (6, p. 23) was the first to note this strand-line at Thames. According to Cussen (78, p. 404), an old beach 17 ft. above sea-level occurs at Maukoro, in the Hauraki Plain, about eighteen miles from the sea. Other raised beaches up to 100 ft. high have been recorded at several points between Auckland and East Cape. Beaches 25 ft. high occur near Thames (45, p. 29) and Tauranga (114, p. 212); at Cabbage Bay, 80 ft. (28, p. 70); north of Cabbage Bay, up to 70 ft. (42, p. 61); at Waihi Beach and Orokawa, near Waihi, up to 50 ft. (48, p. 30); and at Te Kaha Point, 50–60 ft. (17, p. 199). At Opotiki is a tableland 100 ft. above the sea, and according to Smith remnants of beaches from 80 ft. to 100 ft. high occur at intervals from East Cape to Tauranga and along the east side of Hauraki Peninsula (72. pp. 406–8).

Another group of raised beaches is represented by the terrace at the back of the Town of Thames, 150–175 ft. (28, p. 38), at the mouth of Kauaeranga River, and for several miles along the east side of Hauraki Plain. Beach-remnants 200 ft. high occur between Hastings (Tapu) and Kirita Bay (28, p. 70). The ridges of the lowlands west and south of Tauranga Harbour, which are formed of soft Pleistocene deposits, rise regularly inland to about 250 ft.

West of Tauranga, and farther south-east in the Te Puke district, these beds slope gently upward to a plateau which rises regularly to more than 1,000 ft. Towards the sea this surface is deeply incised by the streams and dissected by their numerous branches. Many years ago Hutton noted the gently-undulating high-level plateau near Thames, which he considered to have been formed when the land was about 1,600 ft. lower than at present (6, p. 23). At Hicks Bay fossiliferous sands and muds form wide terraces which extend inland for seven or eight miles and rise from 350 ft. to 650 ft. above the sea. Between Te Araroa and East Cape are gravel-veneered wave-cut benches from 870 ft. to 1,000 ft. high.

East Cape to Wellington.

The slight uplift, the effects of which farther north have been mentioned, also raised the coast from East Cape to Wellington. Marine terraces up to 20 ft. above the sea occur at Tuparoa and at Waipiro, Tokomaru, and Tolaga bays (52, p. 23). They have been recorded at various places in the Gisborne district (7, p. xvi, and 8, p. 120), at Mahia (17, p. 198), Wairoa, Herbertville (34, p. 103), and Palliser Bay (11, p. 85). Crawford observed a series of beaches near Wellington respectively 4 ft., 9 ft., and 15 ft. (61, p. 316) above the sea, and wave-formed caves at Miramar lifted 15 ft. (65, p. 396). Benches somewhat higher, but belonging

to the same group of marine terraces, occur at many points along the northern part of this portion of the coast. They are 50–90 ft. high near the mouth of the Waiapu River, 40–50 ft. at Tokomaru Bay, 90 ft. near Tolaga Bay (52, p. 24), 40 ft. at Makarori Point, and 60–70 ft. near Wairoa. There is a wave-cut bench rising to about 50 ft. near Cape Turnagain, and another at Cape Turakirae up to 95 ft. (90, p. 209). A marine terrace at Mukamuka is 50 ft. above sea-level, and one at Lake Onoke 70 ft. (30, p. 29).

A prominent beach from 240 ft. to 260 ft. above sea-level occurs at Tapuwae Rocks, ten miles north-east of Gisborne (52, p. 23), and terraces at similar heights, though much dissected by streams, near Tolaga Bay, at Tawhiti Hill, and near Port Awanui. Marine terraces belonging to this group also occur near Gisborne, on Mahia Peninsula (17, p. 199), east of Wairoa, and at several points about Palliser Bay (11, p. 85). A gravel-strewn terrace from 200 ft. to 300 ft. above the river extends for ten miles up-stream from the mouth of the Mohaka (69, p. 574).

In this portion of the coast the higher groups of marine terraces are well represented near Wellington. A rock platform, the inland edge of which is from 450 ft. to 500 ft. (104, pp. 136–37) above the sea extends from Baring Head to Orongorongo. Wave-cut benches at this height have not been definitely observed in the soft Tertiary strata that front the sea along the greater portion of the east coast of the North Island, but in the Herbertville and Gisborne districts (52, p. 25) dissected plateau-like uplands rising gradually from about 600 ft. were probably formed when the sea was some 500 ft. or 600 ft. higher. Inland along the Waiapu and Waipaoa Valleys (44, p. 32) are extensive terraces from 400 ft. to 600 ft. above the beds of these maturely graded rivers.

Terraces and gravels in these valleys at a still higher level suggest that at one time the land was even lower. In the Waiapu Valley there is an extensive terrace 900 ft. and more above the adjacent stream-bed, and the even crests and flat tops of the ridges of the uplands between the Waiapu and the coast indicate erosion from an extensive high-level plateau 1,000 ft. or more above sea-level. The top of Cape Kidnappers is a sloping flat, possibly wave-cut, 700 ft. high. Near Wellington a wave-cut bench 950 ft. high occurs at Orongorongo (104, p. 137), and other terraces of unknown but probably of similar height are to be seen on the eastern shore of Palliser Bay (61, p. 316).

Wellington to Auckland (West Coast).

Raised beaches from 10 ft. to 20 ft. above sea-level occur at numerous points along the west coast of the North Island between Wellington and Auckland. Crawford (65, p. 396) has described those near Wellington, and Adkin those at Porirua Inlet (106, pp. 148–53). They also occur near Foxton, Wanganui, Hawera, New Plymouth, Waitara, Mokau (54, p. 13), Kawhia, Raglan, and Manukau (107, pp. 101–2). The railway near Paekakariki is on a gently-shelving slope formed during the last period of uplift. In north Taranaki a sloping surface rises regularly inland from sea-cliffs in places less than 30 ft. high. North of Urenui this plain is reduced to a narrow strip, which continues along the shore as far as Awakino. This gravel-covered bench was first noted by Hector (1, pp. 3–4). It is backed throughout by an ancient sea-cliff, and except where covered with dunes is rarely more than 120 ft. high (54, p. 13). Small remnants of terraces up to 100 ft. above the sea occur at many points between Awakino and Raglan Harbour. Between Raglan and Waikato mouth there are a

few remnants of marine terraces belonging to this period, and the mud-flats of Manukau Harbour continue above water as gentle slopes that rise to 70 ft. or 80 ft.

The 200–300 ft. group of coastal terraces is well represented near Wellington by the Tongue Point platform, which is 240 ft. above the sea (92, p. 255). The low hills west of Evans and Lyall Bays are probably carved from a shelf of this period. Dissected littoral deposits occur near Pukerua Station (267 ft.), north of Plimmerton; and, according to Adkin, raised beaches from 200 ft. to 240 ft. above the sea occur near Levin (89, p. 507). From Marton to Mangaweka the Wellington–Auckland Railway is built on an ancient flood-plain of the Rangitikei River, which stream is now entrenched from 200 ft. to 250 ft. below. In north Taranaki and west Auckland marine terraces of this cycle have been observed at several points. Small remnants 200–260 ft. high occur some miles north of Awakino (54, p. 13); the flat-topped isthmus of the peninusla between Kawhia and Aotea inlets, which is 200 ft. above sea-level, consists of soft sands similar to the banks now forming in the inlets; and thirteen miles north of Raglan a bench 190–230 ft. high, about 4 chains wide, and backed by an ancient sea-cliff, extends for half a mile along the coast.

At Tongue Point there is a terrace-remnant about 450 ft. above the sea (92, p. 256); the flat-topped Mana Island slopes gently up to 440 ft.; and the gravels at Johnsonville and those at Brooklyn and Kelburn probably accumulated when the land was some 400–600 ft. lower. According to Cotton there is a base level of erosion in the Wellington district 800–900 ft. above the present one (92, p. 248). Adkin mentions a 530 ft. beach near Levin, and states that this beach rises to 770 ft. inland from Palmerston North (101, p. 108). McKay (24, p. 2) noted flat-topped spurs formed of soft sandstone, and from 500 ft. to 800 ft. high, south of Shannon. Marshall states that gravels cap hills 500 ft. high near Wanganui (118, p. 47), and Morgan is of opinion that the land in this area was formerly at least 500 ft. lower than at present (103, p. 63). A little north of Urenui a well-dissected gravel-covered terrace rises from 450 ft. to 800 ft. Wave-cut benches from 450 ft. to 650 ft. above the sea extend for miles along the coast north of Awakino (54, p. 13). The Marakopa district has certainly been uplifted 500–700 ft., and an undoubted beach about 615 ft. above sea-level occurs at a point seven miles north of Marakopa (60, p. 183). Mount Karioi, south-west of Raglan, has a sloping plain 450–550 ft. on three sides. Between Raglan and Waikato the sea-cliffs are formed of or capped with dissected littoral deposits, at many points showing broad sloping surfaces 400–600 ft. above tide-mark. Mount Pirongia is flanked on the west by a gently-sloping plateau from 1,200 ft. to 1,400 ft. above the sea, and sands typical of the littoral deposits of this district cap hills up to 1,000 ft. high a few miles south of the mouth of the Waikato.

Cape Farewell to Kaikoura.

In the northern portion of the South Island raised beaches up to 100 ft. high occur at many points. A gently-sloping surface rises from the western shore of Golden Bay to a height of 60 ft. or 80 ft. along the base of the hills (55, p. 14). Collingwood, Takaka, Motueka, Richmond, Nelson, and Blenheim are built on the slightly uplifted deltas of various rivers. According to McKay, Pelorus and Queen Charlotte Sounds were once connected by way of Mahakipawa Arm, which ends in a flat 25–30 ft. above the sea (12, p. 97); the terrace on which Havelock, at the head of Pelorus Sound, is built, and the flats at Cullensville, suggest elevation to the extent

of 40 ft. (21, p. 40). Cotton has remarked on the narrow strand-plain along the east coast of Marlborough (94, p. 293), and Morgan on sea-worn caves 10 ft. to 12 ft. high at Kaikoura (37, p. 20). Here also are wave-cut benches 60 ft. and 100 ft. above the sea. The flats at Kekerangu, according to Cotton, suggest an elevation of about 120 ft. (94, p. 290; see also 16, p. 125).

The 200–300 ft. group of terraces are also represented in this part of New Zealand. A raised beach about 250 ft. high extends across Kaikoura Peninsula; and Cape Campbell is a flat-topped promontory about 200 ft. above the sea (36, p. 19). According to McKay, gold-bearing gravels occur in the Mahakipawa Valley 200 400 ft. above stream-level (21, pp. 41–42), and there are gravel terraces of similar height in the Pelorus and Wakamarina Valleys, a few miles from the head of Pelorus Sound. Marine terraces of this period extend for miles along the south shore of Golden Bay, and rise in gentle slopes to heights of 180–270 ft. along the foot of the hills.

In this locality also are remnants of terraces 400–500 ft. high, and near the tops of the hills are deposits of well-rounded granite boulders and pebbles, 1,000–1,200 ft. above the sea, that could only have been carried to their present position by shore drift. On the southern side of the Riwaka Valley, facing the sea, is an elevated shelf of about the same height. Near the shores of Blind Bay there is no record of the presence of high-level benches. In the Sounds districts, a few miles up the Wakamarina Valley, there are fluviatile gravels about 700 ft. above stream-level (56, p. 12). Downs 600–700 ft. high, formed of gravels, occur south of the Wairau Plain near Blenheim (23, p. 179). The high-level terraces of the Awatere Valley (800 ft. and more above the stream) (94, p. 288), and the ancient delta of the Clarence, 500–600 ft. high (94. p. 291, and 16, p. 125), probably reached their present position by uplift Near Kaikoura are wave-cut benches 450 ft. or more above the sea (37, p. 20). and the so-called Kaikoura Plain, formed by the coalescing of several shingle-fans, rises on the flanks of the Kaikoura Range to more than 600 ft.

Kaikoura to Dunedin.

The low strand-plain of Marlborough occurs at many points for some miles south of Kaikoura. Near the mouth of Conway River are beaches 40–50 ft. (38, p. 24), and at Gore Bay 12 ft. and 80 ft. above the sea (58, p. 174, and 59, p. 26). Speight records recent uplift near the mouth of Waipara River as having produced a plain sloping gently upward to a cliff the top of which rises from 50 ft. to 150 ft. at Amberley (91, p. 222). This latter terrace is probably the same as that recognized by Hutton (9, p. 54–55) near Motunau, some miles to the north-east (80–150 ft.). Haast many years ago recorded the occurrence of raised beaches, up to 20 ft., between Kaiapoi and the sea, at Sumner, and on the south side of Banks Peninsula (110, pp. 49, 52). The delta of the Waitaki River extends for miles north and south along the coast as a low strand-plain of varying width, and at Oamaru rock-cut benches 12 ft. and 42 ft. high are veneered with pebbles, sand, and broken shells (51, p. 112, and 15, p. 65). The flats at the mouth of Shag River are uplifted estuarine beds, and south of this river are marine terraces about 100 ft. high (112, p. 78, and 18, p. 234). The isthmus of Otago Peninsula is formed of raised littoral deposits, and the flats round the shores of the many coastal indentations of this district are of a similar nature.

According to Hutton (9, p. 55) coastal terraces from 200 ft. to 300 ft. high occur between Kaikoura and Conway River. There is a rock-cut bench 300 ft. high south of the latter locality. Morgan (38, p. 24) has noted the presence of platforms about 200 ft. above the sea at Amuri, Conway, and Claverley. A gravel-veneered rock-bench from 220 ft. to 250 ft. high (58, p. 174) occurs at Port Robinson, and a terrace from 200 ft. to 300 ft. above the sea extends for about seven miles between Stoneyhurst and Motunau (13, p. 76). Near Oamaru the strand-plain is backed by old sea-cliffs from 150 ft. to 200 ft. high, from the top of which an extensive plain extends inland along the Waitaki Valley, rising from 230 ft. to over 650 ft. near Papakaio (100, p. 118). Park (51, p. 111) considers that this high-level plain was produced by an uplift of the land of about 200 ft. There are several marine terraces near Seacliff between 200 ft. and 300 ft. high, and Marshall (115, p. 386) mentions a well-defined bench at Sandymount, near Dunedin, 250 ft. above sea-level.

McKay (10, p. 177) observed a 500 ft. terrace at Amuri Bluff with shells on its surface; and Morgan (38, p. 24) records a 400 ft. bench near Claverley, and beach-shingle and sand up to 600 ft. According to Speight and Wild (99, p. 80) a platform 500 ft. high occurs between the Blyth River and Napenape Cliff. The plateau-like uplands above Port Robinson, north of the Hurunui River, were probably once an extension of this latter terrace. Beach-remnants 450 ft. above the sea occur at Lyttelton Heads (85, p. 32), but between this point and Dunedin the only definite record that the sea was once higher is furnished by the plateau, 1,100–1,200 ft. above the sea, on the eastern side of the Malvern Hills (9, p. 57). At Highcliffe, near Dunedin, Hutton long ago noted several rock-benches up to 900 ft. above sea-level (112, p. 78).

Dunedin to Jackson's Bay.

A 10 ft. beach occurs at the mouth of Kaikorai Stream, a little south of Dunedin, and Grange (105, p. 161) considers that the topography of this district suggests an uplift of about 100 ft. There are several low coastal terraces near the mouth of Taieri River. The extensive flats at Inch-Clutha are from 10 ft. to 20 ft. above tidal river-channels. North of Port Molyneux a sand-veneered wave-cut bench which rises gently from cliffs 30–60 ft. high to about 120 ft. at the inner margin of the platform continues along the coast for at least seven miles. Raised beaches up to 20 ft. above the sea have been worked for gold for some miles eastward from Waipapa Point. From Invercargill to Riverton the swampy silt-plains have obviously been recently raised above high-water mark. Petrie (71, pp. 323–24), writes of Stewart Island, " At no remote date a strait here [between Paterson Inlet and Mason Bay] ran across Stewart Island, separating the high land in the north . . . from the southern portion . . . a depression of 50 ft. or 60 ft. would suffice to restore this strait, and part Stewart Island once more into two." According to Hutton (112, p. 80) one of the Green Islets rises from a platform 40 ft. high, at which level is an arch evidently formed by sea erosion. Hector (109, p. 453) many years ago noticed sea-worn caves on Steep-to Island, Preservation Inlet, 10–20 ft. high. An old channel between Chalky and Preservation Inlets is now represented by a flat-bottomed gap 50 ft. above the sea in the separating mountainous peninsula (27, p. 33). At Gulches Head, in Preservation Inlet, there are, according to McKay (27, p. 45), gravels 130–140 ft. above tide-mark. Lake McKerrow, north of Milford Sound, which is separated from the sea by a low gravel spit, has terraces from 10 ft. to 60 ft. high (3, p. 43).

Near Dunedin the 200–300 ft. group of terraces is represented by the gently undulating surface above the cliffs fringing the coast south of the town. East of Kaitangata are beach-remnants 260–300 ft. high, and similar terraces formed of buff-coloured gravels and sands occur at Orepuki, where Park (53, p. 54) states they reach a height of 230 ft. Hutton (112, p. 79) wrote in 1875 that "the chain of small islands between Paterson's Inlet and Ruapuke are quite flat-topped, the result evidently of marine denudation. They are between 140 ft. and 200 ft. high." According to Park (20, p. 130) there is a coastal terrace between Barn Bay and Martin Bay from 100 ft. to 300 ft. above sea-level; and Hector (109, pp. 455, 467) noted terraces near Lake McKerrow, 270 ft. high, and the wooded tableland of Coal Island (200–300 ft.).

The higher group of terraces is not well represented on the east coast of Otago, or at least there is no reference to its presence except by Hutton (112, p. 171), who noted that gravels occur up to a height of 400 ft. on the sea face of the coast range opposite Otakaia. This range extends south to Kaitangata, where its even flat-topped crests appear to have been carved from a plain (600–700 ft. high) sloping gently seaward. A little west of Orepuki are terrace-remnants 400–450 ft. high. In Stewart Island, McKay described the south end of the Tin Range as a broken tableland from 500 ft. to 700 ft. high (22, p. 83), and wrote that the land between Big River and Puysegur Point was a terraced bench from five to ten miles wide rising from 200 ft. to 1,200 ft. (27, p. 32). Marshall states that raised beaches occur in this part of New Zealand up to 1,000 ft. high (119, p. 200). McKay (27, p. 37) noted the presence in this locality of gravel terraces 800 ft. high, and considered that the sea was once 750 ft. higher than now. Hutton (112, p. 80) in 1875 mentioned a series of wave-cut benches up to 800 ft. at the entrance of Doubtful Sound, and stated his belief that Otago had been elevated both on the east and west coasts 500 ft. or more (112, p. 83). Hector (3, p. 43) noted the gently sloping plateau at Cascade Point, that in seven miles rises from 300 ft. to 700 ft.

Jackson Bay to Cape Farewell.

Blacksand beaches up to 60 ft. above the sea have been worked for gold at innumerable points on the narrow strand-plain that extends along the coast for most of the distance between Jackson Bay and Cape Farewell. The towns of Okarito, Hokitika, Greymouth, and Westport, as well as the railways from Ross to Greymouth and from Westport to Mokihinui, are built on this plain. Between Greymouth and Westport the strand-plain occurs at many points. Haast (108, p. 112) observed raised beaches 12 ft. above the sea between the Wanganui and Karamea Rivers, and Cox (14, p. 73) similar beaches 5–20 ft. high between Big River and Westhaven Inlet. Higher terraces belonging to this group are represented by the gravel-bench north of Hokitika (120 ft. on the seaward edge) and the wave-cut platforms at Perpendicular Point (about 90 ft.) and Seal Island (60 ft.) north of Greymouth (50, p. 43).

According to Hector (3, p. 47) the coast south of Paringa River is formed of flat-topped cliffs from 150 ft. to 200 ft. high, of which the upper 50 ft. is gravel. Hacket (5, p. 9) observed similar cliffs in the Okarito district, where they are from 200 ft. to 300 ft. high, formed chiefly of morainic material; north of Okarito is a gravel cliff 100 ft. high (5, p. 10). Auriferous beach leads occur in North Westland in successive terraces up to 220 ft. or more above the sea (2, p. 30; 46, p. 33; 66, p. 296). At Point Elizabeth, north of Greymouth, Darkie's Terrace is over 200 ft. (26, p. 22;

46, p. 44), and still farther north the Barrytown lead and Welshman's Terrace is about 220 ft. above tide-mark (50, p. 43). Bartrum (95, p. 259) has described sloping plains between Charleston and Westport that rise to about 250 ft. at the foot of an old sea-cliff. Near Westport there are beach leads between 200 ft. and 300 ft., and at Gentle Annie Point marine gravels occur about 200 ft. above the sea (49, p. 94). Still farther north, in the Paturau district, there are raised beaches up to 200 ft. high (32, p. 25).

The only reference suggesting that the land in South Westland was once more than 200 ft. or 300 ft. lower than at present is by Hacket (5, p. 10), who observed that the plateau between the Omoeroa and Waiho Rivers, two or three miles from the sea, is about 700 ft. high. Between Greymouth and Westport there is abundant evidence of uplift. North of Point Elizabeth, near Nine-mile Bluff, an extensive marine terrace occurs at a height of over 400 ft. Gold-bearing beach-gravels have been worked at between 500 ft. and 750 ft., near the mouth of Punakaiki River (50, p. 43). Some of the high-level blacksand leads of the Charleston district occur 500 ft. and more above sea-level, and there is, according to Bartrum, a wave-cut bench at 759 ft. (95, p. 258; see also 67, p. 445). Marine terraces belonging to this group are also present in the Westport district (49, p. 94), and platforms 1,000 ft. or more face the coast near Kahurangi Point.

Summary of Evidences of Elevation.

The coastal terraces of New Zealand may evidently be grouped into several sets. Two sets, one comprising raised beaches up to 120 ft. above the sea and the other the terraces from 200 ft. to 300 ft. high, are well marked, and probably were formed during times of comparative slower elevation, rest, or depression occurring in the general elevatory movements of the younger Pleistocene and Recent periods. There is also a prominent set of benches between the 400 ft. and 600 ft. contours. Terraces at a higher elevation are widely scattered and fragmentary or greatly denuded.

As Hector (64, p. 269) observed many years ago, raised beaches up to 25 ft. above sea-level occur at innumerable points round the coast of New Zealand. There are also widely distributed remnants of platforms up to 120 ft., and in sheltered embayments are sloping wave-built terraces rising from sea-level, the landward edges of which, for reasons already given, vary considerably in height. Infilled estuaries show these surfaces (entrenched by streams owing to the latest elevations) most clearly; but in these the distinction between fluviatile and littoral deposits is difficult to make, and the height of the strand, when the period of standstill or depression ended, cannot be determined. On exposed portions of the coast, where, however, owing to the cutting-back of the land by the waves, the complete bench is nowhere preserved, the old strand-line is most definitely marked. The best example of this terrace known to the writer is at Colac Bay, whence it extends westward to the Waiau River. Another bench cut during the 120 ft. standstill in hard early Tertiary rocks, extends for at least seven miles along the coast north of the Molyneux River. In the North Island a narrow strip of a platform cut in beds of Middle Tertiary age extends south from Awakino River for twenty-five miles to Urenui, where it merges in the Taranaki Plain. In these localities the old strand-line of what may be termed the Awakino cycle is about 120 ft. above sea-level The general occurrence at about this height of remnants of wave-formed terraces round the coast of New Zealand, as described in preceding pages, suggests that the Islands were uniformly uplifted to this height.

Again, the presence of steep hillsides, believed to have been derived from old sea-cliffs, along the landward edge of the remnants of this platform, together with the occurrence of a decided break at or some little height above the 120 ft. contour in the more subdued topography of the lowlands occupying sheltered embayments, infilled estuaries, and localities where delta-plains are being extended seaward, suggest that a decided pause in elevation of the land, or even depression, is represented. Haast (110, p. 43) noted this break in connection with the Canterbury Plains, and Cotton in connection with the Manawatu lowlands; both, however, explain it as being probably due to differences in the supply of waste brought to the sea by rivers.

The 200–300 ft. group of benches, except in North Auckland, is well represented at many points round the New Zealand coast. Where wave-attack has been the rule only remnants occur, but in sheltered localities the sloping surfaces are more extensive. As far as the writer knows, sea-cliffs everywhere back the wave-cut platforms, but where the terrace is chiefly wave-built no definite break in the land profile has been observed. The bench is particularly well preserved at Tongue Point, near Wellington; at Tapuwae Rocks, ten miles north-east of Gisborne; and near Crayfish Point, thirteen miles north of Raglan. In the South Island it is well shown on Golden Bay, between Collingwood and Takaka, between Westport and Charleston, at many points in North Westland, and, according to McKay, between Stoneyhurst and Motunau. The terraces belonging to this group are decidedly dissected by streams, and their inner edges are concealed in most localities by later debris, but seemingly the stillstand or slight depression of the land they mark occurred at about the 260 ft. contour. The coastal terraces of this period may be considered to belong to the Tongue Point cycle, a term first used by Cotton (92, p. 250) in connection with the physiography of the Wellington district.

The terraces higher than those of the Awakino and Tongue Point cycles may be divided into two groups—namely, those between 350 ft. and 600 ft. and those still higher. The lower group is represented by remnants decidedly better preserved than the benches of the higher group; but these in turn are much more dissected than those of the Awakino and Tongue Point cycles, although both the higher groups of platforms, on the evidence of extensive dissected upland surfaces, represent decidedly longer periods of comparative standstill.

Terraces of the 350–600 ft. group occur at various points all round the coast of New Zealand, but, so far as known to the writer, are best represented north of Raglan and again at Hicks Bay (formed of Pleistocene sand), north of Awakino (carved from Tertiary rocks), between Palliser Bay and Wellington Harbour (carved from greywacke), near Charleston, at Cascade Point in South Westland, and at the mouth of the Clarence River, where they represent the uplifted delta of that stream. There seems to have been a considerable pause between 400 ft. and 450 ft., for wide terraces at that height are preserved at most of the localities mentioned; but no considerable topographic break occurs from the 350 ft. to the 600 ft. contour. Between Charleston and Westport the inner edge of this terrace at many points abuts against steep hillsides, presumably old sea-cliffs. This suggests that a definite pause occurred in the elevatory movements at about the 600 ft. contour. The name "Charleston cycle" is suggested for the cycle to which the 400–600 ft. group of terraces belongs.

Marine terraces and other land-features formed when New Zealand was more deeply depressed than 600 ft. below present sea-level are represented

by widely scattered remnants. Definite benches are best preserved near Te Araroa, at Orongorongo, near Collingwood, and in the south-west corner of Otago. The cycle to which they belong has been termed by Cotton the "Kaukau cycle" (92, p. 249).

The above facts support the suggestion that New Zealand has moved in respect to sea-level during later Pleistocene and Recent times as a whole. Any differential movements between adjacent earth-blocks that may have taken place during these periods must have been small, if compared to the plateau-forming movements by which New Zealand has been uplifted as a unit.

EVIDENCES OF DEPRESSION.

The numerous embayments and branching indentations on both sides of North Auckland Peninsula definitely prove the depression of this part of New Zealand. A bore on the flats at the northern end of Kaipara Harbour penetrated 212 ft. of river silts and estuarine beds (88, p. 458) without reaching solid rock, but beyond this record there seems to be no evidence as to the amount of the depression. Ramifying inlets occur also along the west coast as far south as Kawhia. Hochstetter (111, p. 273) long ago pointed out that the Waikato has completely filled in a similar inlet. This at one time extended inland as far as Huntly, over thirty miles from the sea. Here a band of marine shells in unconsolidated estuarine beds 67 ft. below sea-level (39, p. 31) was passed through by a bore. A slight depression would create an extensive inlet about Waikato mouth; on the other hand, a slight elevation would convert the greater part of the harbours from Manukau to Kawhia into dry land. Although the straight cliffed coast between Raglan and Waikato Heads has been cut back by the sea, all, save the smallest streams, are tidal at their mouths, and flow through swampy flats produced by the recent slight uplift of their infilled estuaries.

Some of the valleys drowned to form the Aotea and Kawhia inlets have been cut in a marine terrace up to 220 ft. high, and have since been partly filled with sands and muds to the present 105 ft. contour. Evidently, after the 200–300 ft. coastal bench had been formed the land was considerably elevated, and the valleys thereby produced partly filled in during a later depression when the land was 100 ft. or more lower than at present. The coast between Kawhia and Waitara is similar to that between Raglan and Waikato Heads; and the rivers, which are tidal at their mouths, enter the sea through infilled estuaries. The Mokau, the largest river, is tidal for twenty-four miles, and near its mouth there are extensive mud-flats bare at low water. Its estuary, therefore, is not yet completely filled (54, p. 13).

Submerged forests with peat and lignitic beds are exposed on the coast of Taranaki a mile and a half east and two miles west of the Waitara (47, p. 26), and near the mouths of the Patea and Waitotara Rivers (19, p. 59; 62, p. 158; 98, p. 416). The carbonaceous material is overlain by clays, sands, and gravels, usually stained with iron oxide from the oxidation of ironsand derived from the volcanic rocks of Taranaki. According to Park (19, p. 60) the lignitic beds nowhere are found more than a mile or two from the present coast. They probably represent the vegetation of the old land-surface smothered by littoral deposits during the depression that ceased when the 120 ft. coastal terrace was formed.

Wanganui is built for the most part on the raised estuarine flats of the river. At the town, bores have shown that the infilling beds extend at least 172 ft. (77, p. 348), and near Aramoho, three miles up-stream, about 100 ft. below sea-level (82, p. 452). At Longburn (81, p. 552), near Palmerston North, beds of sand and shingle occur to a depth of nearly 300 ft. below

sea-level. Porirua and Wellington Harbours prove the depression of the southern end of the Island. According to Cotton, the depression on the eastern side of Wellington Harbour is about 200 ft. (104, p. 140). Palliser Bay, like Wellington Harbour, occupies part of a tectonic depression, and once extended some miles up the Wairarapa Valley, as is proved by the raised shell beaches that occur round the shores of the lake (11, p. 86). That the land has been higher in this locality is suggested by the wide low lying plains and the sprawling spurs that project into them.

The streams flowing to the eastern coast of Wellington are all small. The Akitio and Wainui (34, p. 103), and probably others also, near the sea, flow slightly entrenched in raised estuarine deposits. Hill has shown that the extensive Heretaunga Plain is an old extension of Hawke Bay filled with detritus brought down by the Tukituki, Ngaruroro, and Tutaekuri Rivers (74, p. 288; 76, p. 431). The silts, sands, and gravels of the plain reach 369 ft. below sea-level at Havelock (84, p. 444). The lower valleys of the Wairoa, Waipaoa, Uawa, and Waiapu Rivers are all obviously infilled estuaries (52, p. 22). The loose deposits in the Waipaoa Valley at Makauri, on the flats four miles from the sea, extend to 200 ft. below sea-level (86, p. 434).

In the Bay of Plenty the harbours of Ohiwa, Tauranga, and those on the eastern side of Hauraki Peninsula amply prove depression. At Tauranga, valleys cut in a 200–300 ft. bench have later been depressed and partly filled. The submerged forest at Opotiki (50 ft.), and the swamps at Coromandel (150 ft.) (29, p. 12), and near Thames (30 ft.) (116, p. 244), probably belong to a late period of oscillation. Hauraki Gulf, like Palliser Bay, is the drowned portion of a structural depression. The numerous peat-beds passed through by bores on the lowlands south of the inlet prove a depression of this portion of New Zealand of at least 400 ft. (117, p. 6). At Horotiu, in a tectonic trough adjacent to the Hauraki depression, peaty beds occur at a depth of 550 ft. below sea-level (96, p. 614).

The coast round Golden and Tasman Bays has obviously been depressed. On the shores of the former Parapara, Onekaka, and Onehau inlets are partly filled drowned valleys carved in a raised terrace of the 200–300 ft. standstill. Croixelles Harbour and the sounds are definite proof of the depression of the Marlborough Peninsula. The pattern of the valleys now forming the inlets indicates that they were excavated along a system of parallel faults. Thus the valley-floors of relatively small streams became maturely graded in relatively short periods, so that, when depression occurred, the sea penetrated unusually long distances. The Pelorus River has filled in several miles of its old narrow estuary, and has produced decided shoaling for eight miles below the present head of the sound. But the drainage area of Queen Charlotte Sound is so small that only a trifling amount of infilling can have occurred. Cotton (93, p. 216) has discussed the amount of depression of this area, and considers it to have been from 250 ft. to 500 ft. The neighbouring lower valley of the Wairau River is an infilled estuary. This low-lying area is primarily of tectonic origin, but the choking with debris of minor valleys excavated in Pleistocene gravels south of Blenheim suggests recent depression unconnected with the earlier structural movements.

From Wairau River to Motunau there is convincing evidence of uplift, but the only definite recorded evidence that the land was once lower than now is furnished by the submerged forests at Grassmere (68, p. 97) and near the mouth of Conway River (4, p. 40). The embayments, however, in the rock-platform surrounding Kaikoura Peninsula and the lower valley of Kahutara Stream suggest depression. Farther south the drowned valleys

of Banks Peninsula and the peat-beds 600 ft. below sea-level, penetrated by bores in the Christchurch area (85, p. 29; 88, p. 427; 97, p. 385), definitely prove depression. Some of these bores, before reaching the peat and shingle deposits of terrestrial origin, passed through sandy beds containing shells to a depth of about 80 ft. (88, p. 428). This suggests a depression of at least 80 ft. after the land had been built up above the sea. In the Chertsey oil-bore gravel occurs to a depth of 1,500 ft., and oxidized sands (88, p, 423) and clays to 1,800 ft. below sea-level (41, p. 12). According to Speight, a submerged forest occurs near the mouth of Pareora River, and valleys near Timaru have been depressed below sea-level. All the larger streams entering the sea between Oamaru and Dunedin have infilled estuaries at their mouths. The drowned valleys of Otago Harbour and the numerous inlets of this neighbourhood furnish undoubted evidence of depression. The sea once penetrated through the lower Taieri Gorge into an inlet which is now occupied by the Taieri Plain, and of which Waihola Lake is a portion not yet filled to sea-level. Similarly, Lakes Kaitangata and Tuakitoto are infilled portions of an arm of a drowned valley. Between Nugget and Waipapa Points are numerous inlets and estuaries, of which Newhaven and Waikawa are the chief. The depression of Stewart Island is obvious, and on the north side of Foxeaux Strait are Bluff, New River, and Aparima inlets. Waiau River has cut a valley, three miles wide at present sea-level, through the deposits laid down during the 200–300 ft. standstill. This it has since filled with gravel, the terraces bordering its flood-plain being up to 30 ft. high.

The West Coast fiords are drowned glacial valleys which are all decidedly shallower at or near their mouths than farther inland. The entrance of Sutherland Sound is almost completely blocked with sand and gravel, and tidal waters enter only the lower end of Lake McKerrow, which is also a depressed glacial valley, with a floor, at its upper end, 450 ft. below sea-level (3, p. 44). With the exception of Preservation Inlet, which nowhere appears to be more than about 300 ft. deep, the floors of the fiords are from 800 ft. to more than 1,700 ft. below the surface of the sea. That the glaciers overdeepened their valleys to this extent is unlikely, and the bulk of the excavation was probably done when the land was about 1,500 ft. above its present level. The submarine bars have been explained as moraines deposited as the ice retreated, but they may have accumulated as coastal drift during ancient periods of standstill, or they may be formed of both deposits. There is no mention in the literature of moraine at the sea ends of Lake McKerrow and Sutherland Sound, which are thought to have been choked during the present period of inconsiderable movement.

The immense amount of gravel carried to the sea by the Westland rivers and distributed northward along the shore by the coastal drift has filled in the estuaries that at one time no doubt existed along the shore. Ross Flat occupies an embayment, and beneath it gravels, apparently of fluviatile origin, have been penetrated by a shaft to a depth of 265 ft. below sea-level (31, p. 24), and worked for gold to 191 ft. Blacksand beach leads occurring below sea-level have been sluiced and elevated or dredged at several points in the Okarito, Hokitika, Greymouth, Barrytown, and Westport districts, and bores near the mouth of Waimangaroa River penetrated ...vel and sand to a depth of 80 ft, without reaching solid rock (49, p, 187). ...ast (108, p. 112), noted a submerged forest a few miles west of Westport. ...all coves in granitic rocks near Charleston appear to be drowned valleys, as Westhaven Inlet, at the northern end of the Island, is undoubtedly.

At Kawhia, Tauranga, Golden Bay, and Waiau Mouth valleys, now in part drowned or infilled, were excavated, when the land was at a higher level than now, in the deposits and coastal terraces formed during the 200-300 ft. standstill. At Kawhia the valleys are filled with sands and silts to a height of over 100 ft., so that there has been a later depression of that amount. This was almost certainly the same depression and pause during which the 120 ft. coastal terraces were formed. At the other localities mentioned no precise observations as to the amount of infilling have been made.

The buried forests and old land-surfaces at Thames, Coromandel, Opotiki, and Gisborne, and those of the Hamilton (70, p. 36; 73, p. 459; 75, p. 410), Taranaki, and Christchurch districts, probably belong to this period of oscillation. The submerged forests of other parts of New Zealand, most of which occur at sea-level on the coast, may have been formed during slight movements of still more recent date. This especially applies to the scrub-covered land-surfaces occurring a little below high-tide mark in Manukau, Raglan, Aotea, and Kawhia inlets.

The inlets last mentioned, together with those of Kaipara and Tauranga, are formed by the drowning of valleys in part carved in Pleistocene deposits; Tauranga is entirely in these beds. They correspond in size among themselves, and also to other inlets round the coast of New Zealand formed by the drowning of stream-valleys. This suggests that all these features were produced by the same movement of depression, which occurred between the Tongue Point and Awakino erosion cycles. There are, however, no data by which the depths of these drowned valleys can be compared, since all, except the Marlborough Sounds, are largely infilled. Cotton concluded that these last-mentioned inlets had been produced by a subsidence of the land of between 250 ft. and 500 ft., and such bores as penetrated the beds deposited in the drowned valleys do not contradict this conclusion.

The layers of vegetable material and the other terrestrial beds that are penetrated by the deeper bores at Christchurch and Chertsey probably belong to the Middle Pleistocene period. Progradation of this portion of New Zealand was continuous throughout Pleistocene times. At Chertsey gravels and sands more or less oxidized extend to 1,500 ft. below sea-level, at which depth they pass into sands and clays probably of marine origin. It should be noted that the bottoms of several of the fiords of western Otago are at a similar depth below sea-level. In the North Island the greatest known depth at which surface deposits occur is in a bore at Horotiu, in the Hamilton district, where peat-beds occur 550 ft. below sea-level. This bore when abandoned was still in unconsolidated deposits which had accumulated in a tectonic depression. At Thames, in an adjacent structural trough, loose sands and silts are known to occur to a depth of 1,100 ft., but those beds do not furnish proof that the land in this area was ever elevated to this extent.

Post-Tertiary Volcanic Rocks.

The post-Tertiary volcanic rocks of New Zealand are confined to the North Island. They consist of the three following groups: (1) Basaltic rocks that occur at many points near the west coast from Kawhia to Auckland and in North Auckland Peninsula; (2) rhyolitic flows, breccias, and tuffs that cover large areas in the Taupo-Rotorua zone, and occur near Waihi and probably other parts of Hauraki Peninsula; and (3) the andesitic cones of Egmont, Ruapehu, and adjacent mountains, Edgecumbe, White Island, and probably other volcanoes.

Basaltic Rocks.

The basaltic rocks range in age from the oldest Pleistocene to Recent times. The first eruptions appear to have been closely associated with the great fault-movements that separate the Tertiary from the Quaternary. The large cones of Pirongia and Karioi occur at crossing-points of important fracture-systems. The former fills part of the trough the drowned western end of which forms Kawhia Harbour. The building of these mountains and the cones associated with them was certainly completed after movement along the great fracture-zones of this part of New Zealand had ceased; the volcanic rocks of this group rest for the most part on land surfaces; and the youngest Tertiary rocks of the district (the late Pliocene Kaawa beds) contain no trace of basaltic material. On the other hand, the high-level shelf (1,200–1,400 ft.) on the west flank of Pirongia shows that the mountain existed at the maximum depression separating the early from the younger Pleistocene. For these reasons Pirongia, Karioi, Kakepuku, Te Kawa, and various lava-flows and dykes between Raglan Harbour and Waikato Heads are considered to be of early Pleistocene age.

Some of the basaltic rocks of this district are certainly of later date. Scoria-cones with associated lava-flows occur in valleys that were excavated during the last considerable elevation. They are connected through the volcanic rocks of the Tuakau with the basaltic cones and lavas of Auckland. But the eruptions at Auckland were later, since the cones still have well-preserved craters and the scoria is unweathered, whereas the cones south of the Waikato show no trace of craters and consist of deeply-weathered rock.

The basaltic rocks of North Auckland, which chemically and mineralogic ally resemble those of Pirongia and Tuakau, are divided by Clarke into two closely-connected groups. They probably range through the Pleistocene to Recent times.

Rhyolitic Rocks.

Large amounts of rhyolitic material were erupted during late Pliocene times, but probably the bulk of the acid rocks in the Taupo-Rotorua zone is of Pleistocene age. Although flow rocks are abundant near the centres of vulcanism, fragmental material is much more widespread, and occurs in greater mass. Thick layers of rhyolitic tuff and breccia of subaerial deposition cover large areas in the centre of the North Island and completely smother the underlying rocks. On surrounding districts extending to the east and west coasts finer material, in many parts weathered to a characteristic sandy loam, caps the hills and upland surfaces. Subaqueous tuff and breccia are interbedded with subaerial, and, in low-lying country towards the edge of the area of thickest deposition, almost entirely replaces it. Beds of this description occur in vast amount in the Waikato and Hauraki depressions, near Tauranga, and eastward in the Bay of Plenty, and in less amount in the Waipaoa and Wairoa Valleys. In the Waikato district the subaqueous rhyolitic tuffs contain water-worn fragments of basalt, and wrap round and overlap the bases of several of the basaltic cones. Clearly the earliest basalts are older than this rhyolitic material.

Andesitic Rocks.

The great volcanoes of the centre of the North Island, Ruapehu and Tongariro, together with the small adjacent cones, are formed of andesitic material, and overlie the rhyolitic rocks mentioned above. In the Waihi district massive andesitic dykes penetrate the later rhyolitic fragmental rocks (48A, p 75).

The active volcanoes, Ngauruhoe, White Island, and Tarawera, all discharge andesitic material. The ash produced by the explosive eruption of the last-mentioned was chiefly derived from the rhyolitic rocks through which the line of vents was formed, and was, consequently, acidic in composition. Probably the large amount of rhyolitic sand brought down during Recent times by the Waikato and other rivers flowing from the Taupo region was similarly produced from older acidic rocks by the explosions of andesitic volcanoes. The loose pumiceous sands and gravels about Lake Taupo, and the unweathered rhyolitic ash found over the country eastward, were probably blown out at the same time.

The andesitic cone of Mount Egmont rises from a volcanic pile of decidedly older rocks of similar composition. Its relation to the rhyolitic rocks is nowhere shown. But on phyisographic grounds it is clearly of Recent origin; and, since its rocks are of similar composition to those of the central volcanoes, this mountain is considered to be of about the same age. The Taranaki Plain surrounding Mount Egmont is covered with tuff derived from it. In the Mokau district, about fifty miles north-east of the peak, the 120 ft. coastal terrace, which is in direct continuity with the Taranaki Plain, is formed of or veneered with similar material more or less sorted by wave-action. On the other hand, the higher coastal terraces of this district are covered with siliceous sands containing pebbles of greywacke, but no trace of andesitic material. The coastal drift is northward, and had Egmont been active while the higher marine shelves were being cut the detritus on them could scarcely have failed to contain some trace of volcanic material. Probably, then, the last eruption of the Taranaki volcanic centre, which presumably produced the peak of Egmont, was associated with the Recent land oscillations that produced the 120 ft. coastal terraces.

Conclusion.

The deposits of Pleistocene and Recent age are, in New Zealand, of greater economic importance than those of all other ages. The plains, river-valleys, and lowlands generally were formed or profoundly modified, and the soils that cover them were produced during these periods. During the same time, too, practically all the detrital gold won from the gravels of the South Island was liberated from a hard matrix and concentrated into workable deposits. New Zealand boasts of its abundant water-power, which is derived from streams that have not yet, owing to the recency of land uplift, cut their valleys to grade. And in this connection the vast mass of rhyolitic material which, ejected by Pleistocene volcanoes in the centre of the North Island, acts as a porous sponge and regulates the flow of rivers is of special interest. On the other hand, land-depression has provided harbours and valuable artesian basins in many parts of the Dominion.

Literature.

The official geological reports dealing with New Zealand occur scattered through various publications. A central Geological Survey was established in 1865, and the reports of the officers were issued with more or less regularity up to 1894 independently of other publications. After that date they appeared as parliamentary papers, and were bound with the volume of reports, records, &c., issued yearly by the Mines Department. The Geological Survey was reorganized in 1905, since which year, in addition to the annual report printed as a parliamentary paper, bulletins dealing

with areas examined in detail have been published as prepared. The *New Zealand Journal of Science and Technology*, founded in 1918, provides a more accessible and popular record for official reports than parliamentary papers, and many special reports prepared by officers of the Geological Survey are published therein. The *Transactions and Proceedings of the New Zealand Institute* contain much information on the geology and physiography of New Zealand, as also do other publications of which the titles are given below in full.

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Evidences of Pleistocene Glaciation at Abbotsford, near Dunedin.

By Professor JAMES PARK, F.G.S., F.N.Z.Inst., Dean of the Faculty of Mining at Otago University.

[*Read before the Otago Institute, 13th November, 1923; received by Editor, 3rd December, 1923; issued separately, 28th August, 1924.*]

In an excellent thesis* on "The General and Economic Geology of Green Island Coalfield," Mr. L. I. Grange, M.Sc., A.O.S.M., briefly discusses the origin of certain clayey boulder-beds at Abbotsford, a few miles south of Dunedin. Referring to the published views of different observers, including my own,† he says, "The presence at Abbotsford of well-rounded boulders consisting of dolerite, basalt, trachydolerite, and rarely phonolite rocks at the base, all of local origin, is very damaging to the idea of classing the deposit as a boulder-clay. Had the beds a glacial origin boulders of schist would naturally occur, since that rock outcrops at no great distance from the clay."

The aforesaid boulder-clay formation occupies the floor and slopes of the Abbotsford basin. From about 100 ft. above the sea it rises gently northward to a height of 475 ft. Generally it ranges from a few feet to 40 ft. thick, and rests unconformably on the denuded surface of the Tertiary greensands, Burnside marl, and drab-coloured sandstone underlying the marl. The character of the deposit changes with astonishing rapidity from blue clay with boulders to a yellowish-brown clay and rock-rubble.

The base of the deposit is generally a stiff blue clay that contains widely scattered boulders. In places the clay is streaked or intercalated with

* *Trans. N.Z. Inst.*, vol. 53, pp. 157–74.
† The Great Ice Age of New Zealand, *Trans. N.Z. Inst.*, vol. 42, pp. 580–612.

black peaty layers in which, notably at the new Silverstream dam, occur a few prostrate tree-trunks of the genus *Nothofagus*. In the peaty clay near Abbotsford Railway-station and at the new dam occur decomposed moa-bones.

In reference to Mr. Grange's remarks, I wish to say that few or none of the boulders I have seen in this deposit occur in the condition usually described as "well-rounded." The majority are rounded, a considerable proportion semi-rounded, and many slabby and angular. All the rocks are volcanic, and the rounded forms are, to my mind, the result of decomposition and exfoliation, a common occurrence with all igneous rocks. Even with residual clay still in place the undecomposed cores of rock are usually rounded or spheroidal as a result of slow underground decomposition.

The blue clay passing upward becomes yellowish-brown by oxidation, and resembles an ordinary, residual brick-clay. It contains scattered boulders, some of which are 4 ft. or more in diameter. Many varieties of volcanic rock are, however, represented among the boulders; and this, together with the peaty matter and tree-trunks, precludes the possibility of the boulder-clay being a residual clay, of which, be it said, there are many fine examples *in situ* on the Maori Hill ridge above Dunedin.

As viewed under the microscope the silt that occurs as pockets in the blue clay is seen to consist of fresh rock-flour. The blue clay itself occurs in sporadic pockets at different altitudes, and I can only conclude that it accumulated in hollows where the glacial waters were ponded by ice-dams.

The reference by Mr. Grange to the local origin of the boulders was evidently made under a misapprehension. I have examined boulder-clays on the northern foothills of the European Alps and Vosges Mountains, in Aberdeenshire and Morayshire, in the lake country of England, in north Wales, on the foothills of the Canadian Rockies, and on the shores of Puget Sound. In common with many other observers, I found that where the regional glaciation had been free of the influence of the northern ice-sheet the constituent boulders were of purely local origin; and, of course, in New Zealand it could hardly have been otherwise.

Mr. Grange further remarks that, had the beds in question a glacial origin, boulders of schist would naturally occur in them. This also would appear to be the result of a misunderstanding. The Abbotsford basin is ringed on three sides by high hills crowned by volcanic rocks, while the schist occupies only the lower ridges near Ferntown, to the south.

If the flow of the ice had been from south to north one would certainly expect to find boulders of mica-schist in the boulder-clay formation; but there is nothing whatever to show that this was the case. On the contrary, it seems more reasonable to believe that the ice flowed southward from the relatively higher Flagstaff gathering ground towards the Ferntown schist, than to conceive that the flow was northward and up-grade against the superior weight of the ice descending from the Flagstaff volcanic area. In my paper on "The Great Ice Age of New Zealand" I stated my belief that the flow was towards the south—that is, towards the schist area. I may here add that I know of no agency other than ice capable of forming such a heterogeneous deposit as the Abbotsford boulder-clay. Mr. Grange does not help us with any constructive suggestion as to its origin.

A recent re-examination of the deposit in question more fully than ever confirms me in my view of 1910.

A New Fossil Gasteropod from New Zealand.

By A. E. TRUEMAN, D.Sc., F.G.S., University College of Swansea.
Communicated by J. Marwick.

[*Read before the Wellington Philosophical Society, 10th October, 1923; received by Editor, 23rd November, 1923; issued separately, 28th August, 1924.*]

THROUGH the kindness of Mr. John Marwick the writer has been able to study a small series of fossil gasteropods collected recently by Mr. M. Ongley, of the New Zealand Geological Survey. The fossils were collected from some limestones in the Mangarua Creek, in the Tapuwaeroa Valley of the East Cape District, North Island. Mr. Marwick informs me that "no work has been done on the fauna of the beds from which the specimens come, so the age cannot be stated. It has generally been considered as Cretaceous (probably Lower), because of the frequent occurrence of large *Inoceramus*; several of the Mollusca seem to have Jurassic affinities, so the horizon is an open question."

The material submitted to the writer included about thirty more or less fragmentary gasteropods, most of which were embedded in a peculiarly hard pale-blue limestone. With the gasteropods were fragments of several lamellibranchs, including *Inoceramus*.

The writer believes that the gasteropods are distinct from any species that have hitherto been described; they are here called *Katosira obliquestriata* n. sp. No one specimen exhibits all the characters, but as the specimens vary considerably among themselves it will be advantageous first to describe the holotype in detail.

Katosira obliquestriata n. sp.

Dimensions of holotype: Length of shell (estimated), 35 mm; width of shell, 33 per cent.; length of spire, ? 70 per cent.; spiral angle, 106°; apical angle, 24°.

The holotype (fig. *a*) is a fairly complete specimen, but the uppermost whorls are missing, as in all other large specimens that have been extracted from the matrix. Whorls are rather flat, the widest part being near anterior end; sutures are shallow, and there is a tendency for last whorl to be moulded on preceding whorl.

Shell practically smooth; ornament consists of very fine axial striae and a few faint spirals. Axial striae regularly spaced, and after curving slightly to right from posterior border they swing very sharply to left and cross whorl with a marked obliquity. Spirals are few in number, and exceedingly faint except near sutures.

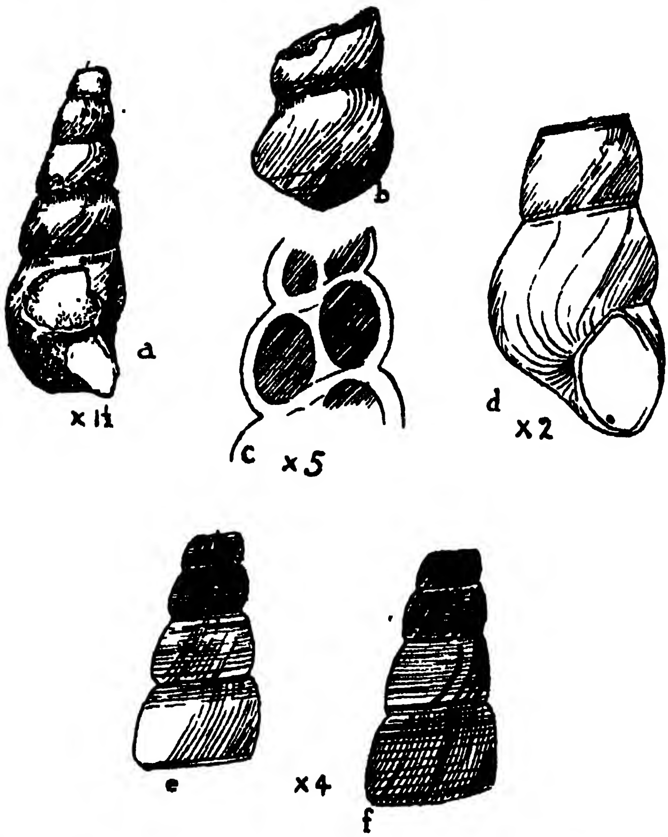
Six whorls present in holotype. These show a slight change in whorl-shape during development, earlier whorls being somewhat flatter than later. Except for the strengthening of spirals near sutures in later whorls, there is no change in character of ornamentation in whorls that are preserved. Anterior part of last whorl (the underside or base of shell) bears axial striations crossed by extremely faint spirals.

The shell is unusually thick.

Holotype: The holotype is in the N.Z. Geological Survey collection. A topotype has also been presented to the British Museum of Natural History.

Several additional features are better shown by other fragments. On two the form of the aperture can be made out, though it is not quite complete in any specimen. It is oval in shape, and appears to be quite holostome, with no trace of a sinuosity (fig. *d*).

Several specimens have been sectioned, and these show that the columella is solid, and oblique to the axis of the shell, although the degree of obliquity varies somewhat in different individuals (fig. *c*).



Katosira obliquestriata n. sp. *a*, holotype; *b*, a specimen showing embracing whorls; *c*, section of a shell to show the columella; *d*, a specimen showing form of aperture (slightly restored); *e*, *f*, diagram of ornamentation on upper whorls (*f*, a paratype).

One specimen, represented only by a single whorl, indicates that the species attained a much larger size than is shown by the holotype; its length may have been more than 60 mm.

Some smaller fragments show the earlier whorls. Two such are shown in figs. *e* and *f*; the latter will be taken as a paratype. The protoconch is not preserved, and the earliest whorl is perhaps the third. This is ornamented by about eight fine regularly-placed spirals, crossed by a number of strong axial costae, which are most pronounced near posterior border, and which are sharply inclined across whorl. On succeeding whorl ornamentation is of the same character, but costae are not quite as strong and are more widely spaced, while spirals are more numerous. On a later (? fifth) whorl costae are replaced by low folds or subcostae, and

ultimately disappear completely, sixth whorl being ornamented only by spiral lines and oblique growth-lines. On this whorl the spirals are very fine and numerous, those near sutures being somewhat stronger than those on middle of whorl. It may be suggested that this corresponds with the earliest whorl shown imperfectly in holotype.

The ontogeny of *K. obliquestriata* may therefore be summarized as follows:—

	Ornamentation.*	Whorl-shape.
Protoconch ..	Unknown	Unknown.
? Third whorl ..	Axial costae and spirals ..	Round.
Fourth whorl ..	Feebler costae and spirals ..	Round.
Fifth whorl ..	Spirals and subcostae ..	Round.
Sixth whorl ..	Growth-lines and spirals ..	Flatter.
Seventh to tenth whorl	Growth-lines and spirals near sutures	Flat.
Eleventh whorl ..	Growth-lines and spirals near sutures	More tumid; whorls embracing.

Variations.—As remarked, there is considerable variation among the specimens, even in one piece of matrix. This is chiefly due to the acceleration or retardation of those progressive characters that are summarized in the above table. Thus in some specimens the whorl-shape at any given stage is more or less advanced than indicated in the table. As the acceleration of ornament takes place independently of the changes in whorl-shape, a great number of variants may be recognized. In some specimens the whorls remain flat throughout, and there appears to be no tendency for the whorls to be moulded on the preceding ones: in other specimens this stage is attained by the sixth or seventh whorl.

The variation in acceleration of ornamentation is equally distinct. For instance, fig. *e* illustrates the early whorls of a specimen in which the costate stage is lost by the fourth whorl; in several specimens the stage with spirals is retained until the seventh or eighth whorl.

These differences are in several cases so pronounced as to suggest that more than one species is present. Indeed, at one stage in the investigation, before the more complete material had been received, the writer was disposed to refer the fragments to at least two species of different genera. As they occur together, however, and as the variation in each character appears to be continuous, it is more satisfactory to regard them as members of one gens or species-group. The writer believes that members of the same species-group collected at one horizon not infrequently show such differences, due to differential acceleration of progressive characters. Such differences in isochronous members of one "lineage" have been noted in several divisions of the Mollusca.

It may be admitted that there is a possibility that the specimens dealt with are not strictly isochronous; the limestone may contain fossils of slightly different dates; but, as the specimens are identical in preservation and appearance, it is safer to consider them as contemporaneous until evidence to the contrary is found.

Generic Position.—Mesozoic turriculate gasteropods with predominant axial ornament were formerly placed in *Chemnitzia* or in *Pseudomelania*. *Pseudomelania* is taken to include smooth shells with growth-lines almost straight, while smooth or costate shells in which the axials showed a sinuosity were placed in *Chemnitzia*.

* The more prominent feature in the ornamentation is given first in each case.

It is apparent that the shells now under consideration must be grouped with *Chemnitzia* s.l.—that is, with the family of Loxonematidae—since the growth-striae are far from straight, and since they show costae at one stage of growth. This conclusion is further supported by the obliquity of the columella, and by the tendency of the later whorls to mould themselves on the preceding whorls, a frequent feature of the Loxonematidae.

The genera of this family have been summarized by Dr. A. E. M. Cossmann (1). Miss McDonald and the writer consider that some of the genera are artificial, and, provisionally, are inclined to use the following for Mesozoic gasteropods (2):—

Zygopleura: Whorls convex, sinuous axials, no spirals.
Katosira: As above, but with spirals.
Hypsipleura: Whorls flat, axial ribs straight.

While it is admitted that these genera are far too comprehensive, it is clear that the species from New Zealand must be grouped with *Katosira*, and, indeed, *K. obliquestriata* resembles broadly many catagenetic species of *Katosira* found in the Jurassic rocks of Europe. It differs from all those known to the author in the greater obliquity of its growth-lines. In particular, *K. obliquestriata* resembles some of the species placed by Cossmann in the genus *Anoptychia*, and it may possibly be a derivative of some of these.

The writer therefore regards *Katosira obliquestriata* as a very advanced member of the Loxonematidae, which apparently is rapidly progressing to a non-costate shell. It is not unlikely that *Pseudomelania* (or at least many Jurassic and Cretaceous species referred to that genus) evolved in this way, perhaps at different times, from Loxonematids. But *Katosira obliquestriata* can scarcely have led to a shell with the growth-lines of *Pseudomelania*, and it may perhaps be considered as a parallel development. The Scalidae arose at about the same time as a development of the Loxonematidae (3), but these are characterized by the strengthening of the axial ribs, and the New Zealand specimens must not be regarded as in any way related to such early members of the Scalidae as *Proscala* (4), which is anageneric, progressing from smooth to costate.

Age.—It is to be regretted that these gasteropods afford no reliable evidence of the age of the rocks where they were obtained. Clearly, they resemble Jurassic rather than Cretaceous gasteropods, yet members of the Loxonematidae are not unknown from Cretaceous rocks. Unfortunately, Cretaceous gasteropods are often so badly preserved that their relations cannot properly be made out. Cretaceous shells which should apparently be referred to the Loxonematidae have been described by Stanton (5) and Stoliczka (6), among others, but these shells are costate throughout and are without the oblique growth-lines that characterize *K. obliquestriata*.

The discovery of gasteropods with such distinctly Jurassic affinities in rocks that may be of Cretaceous age is interesting in view of the suggestion, recently disputed by Dr. Trechmann (7), that New Zealand faunas often show archaic features.

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Otoliths of Fishes from the Tertiary Formations of New Zealand.

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Communicated by Professor W. N. Benson.*

[*Read before the Otago Institute, 13th November, 1923; received by Editor, 3rd December, 1923; issued separately, 28th August, 1924.*]

Plates 61, 62.

THE material for the following paper, which I received through the kindness of Professor W. N. Benson, of the University of Otago, Dunedin, consisted of fifty-six specimens of otoliths, the property of the Geological Survey of New Zealand, and seventy-one otoliths collected by Mr. H. J. Finlay, M.Sc., of the University of Otago, to whom I am also indebted for a list of the formations, in their proper sequence, from which they were obtained. I wish also to acknowledge the great assistance I have received from Professor Benson in his letters, and from the literature he has so kindly sent me on the present nomenclature and correlation of the various systems of New Zealand.

The list of the localities and probable age of the beds from which the otoliths have been obtained are as follows :—

Oamaru Series—

1. Waikaia (Lower Miocene or Oligocene).
2. Wharekuri (Lower Miocene or Oligocene).
3. Clifden (Lower Miocene or Oligocene).
4. Target Gully (Miocene).
5. Ardgowan (Miocene).
6. White Rock River (Miocene).
7. Awamoa (Miocene).
8. Pukeuri (Miocene).

Mokau Series—

9. Tuhua, North Island (Upper Miocene).

Wanganui Series—

10. Castlecliff (Upper Pliocene).

* In the valuable paper which follows the author refrains from deducing from the evidence of the fish-remains themselves any conclusions as to the age of the formations in which they occur. It is interesting to recall in this connection that Windhausen (*Amer. Jour. Sci*, vol. 45, p. 46, 1918) quotes with approval von Ihering's view, based on Patagonian experience, of "the slight value of fish-remains for the decision of stratigraphic problems." Australian geologists have had similar experience in connection with the fish-fauna in the Triassic Hawkesbury System, near Sydney. Presumably the evidence of otoliths only would be still less conclusive, and this, Mr. Frost states in a private communication, is his opinion on the matter. The evidence afforded of faunal relationships is, however, very interesting.—W. N. B.

Mr. Finlay informs me that Nos. 4 and 5 are practically the same horizon, that No. 6 is very near to these, while No. 3 is certainly older than No. 4 but younger than No. 2, and that 7 and 8 are possibly identical horizons and slightly younger than 4 and 5. The occurrence of the different species is quite in accord with his observations. The only species submitted from No. 9 occurs in all other formations up to Target Gully, and that from No. 10, which is very much younger than all the others, is found as low as the Waikaia and in several intervening horizons.

In spite of the small amount of material submitted to me, it is evident that the formations from which it was taken are closely connected stratigraphically.

The amount of material from Pukeuri sent me was much in excess of that from any of the other localities, but of the fifteen species determined from Pukeuri there are examples of five from Ardgowan and four from Target Gully, two from Awamoa, and two from White Rock River.

Otolithus (Scopelus) sulcatus Bassoli (Plate 61, fig. 1) occurs in all the formations from Pukeuri to Target Gully, also in the Mokau series at Tuhua, North Island; *Otolithus (Macrurus) toulai* Schubert (Plate 61, fig. 4) occurs at Pukeuri, Awamoa, Ardgowan, and Target Gully; while *Otolithus (Ophidiidarum) pantanelli* (Plate 61, fig. 8), occurring at Pukeuri, Ardgowan, Target Gully, and Clifden, extends down to Waikaia with five examples, and upwards to the Upper Pliocene of Castlecliff, North Island, from which there is one example. Numerous examples of *Otolithus (Serranus) noetlingi* Koken (Plate 62, fig. 13) occur at Ardgowan and Pukeuri, also *Otolithus (Dentex) subnobilis* Schubert (Plate 62, fig. 18) occurs at both places, while *Otolithus (Sparidarum) elongatus* Priem is found at Target Gully and at Pukeuri. Waikaia and Clifden both furnish examples of *Otolithus (Sparidarum) gregarius* Koken (Plate 62, fig. 17) and *Otolithus (Ophidiidarum) pantanelli* (Plate 61, fig. 8). Two species are found at both Waikaia and at Pukeuri—*O. (Ophidiidarum) pantanelli* and *O. (Dentex) subnobilis*.

Of the twenty-two species determined, fifteen have been recorded from the Tertiary of Europe, the remaining seven being new species. The otoliths of shore-fishes predominate, with seventeen species, compared with five of the deep sea, the latter being fairly numerous, with twenty-one examples of Scopelidae and fourteen of the Macruridae, though only one of *Citharus*.

Tropical species are represented by *Fierasfer*, *Elops*, and *Citharus*, while others represent a subtropical or temperate fauna.

The genera and number of species determined are as follows:—

Scopelus	2	*Pleuronectidorum*	1
Macrurus	2	*Serranus*	3
Physiculus	1	*Parapercis*	1
Raniceps	1	*Elops*	1
Merluccius	1	*Percidarum*	2
Gadus	1	*Sparidarum*	2
Ophidium	1	*Dentex*	1
Ophidiidarum ..	1	*Citharus*	1
Trachinus	1	Inc. sedis	1
Fierasfer	1		—
		Total	22

The incidence of their occurrence is as follows:—

STRATIGRAPHICAL ARRANGEMENT, SHOWING OCCURRENCE OF SPECIES.

Fig.	Waikaia.	Wharekuri.	Clifden.	Target Gully.	Ardgowan.	White Rock River.	Awamoa.	Pukeuri.	Tuhua (N. Island).	Castlecliff (N. Island).
	Lower Miocene or Oligocene.			Miocene.			Upper Miocene.			Upper Pliocene.
	Oamaru Series.								Mokau Series.	Wanganui Series.
1	..	..	..	×	×	×	×	×	×	..
2	..	..	..	×	..	..	..	..	..	..
3	..	..	..	..	..	..	..	×	..	..
4	..	..	..	×	×	..	×	×	..	..
5	..	..	..	..	..	..	..	×	..	..
6	..	..	..	..	..	..	..	×	..	..
7	..	..	..	..	..	..	..	×	..	..
7A	..	..	..	..	..	..	..	×	..	..
8	×	..	×	×	×	..	..	×	..	×
9	..	..	..	..	×	..	..	×	..	..
10	×	..	..	..	..	..	..	..	..	..
11	..	..	..	×	..	..	..	..	..	..
12	..	..	..	..	×	..	×	..	..	..
13	..	..	..	..	×	..	..	×	..	..
14	..	..	..	..	..	..	..	×	..	..
15	..	..	..	..	..	..	..	×	..	..
16	..	..	..	×	..	..	..	×	..	..
17, 21	×	..	×	..	..	..	..	..	..	..
18	×	..	..	..	×	..	..	×	..	..
19	×	..	..	..	..	×	..	..	..	..
20	..	×	..	..	..	..	..	..	..	..
22	..	..	..	..	..	..	..	×	..	..
23	..	..	..	..	..	..	..	×	..	..

Otolithus (Scopelus) sulcatus Bassoli. (Plate 61, fig. 1.)

Dimensions.—5 × 4 mm.

Description.—Shape ovate; outer side flat, inner side slightly convex; rostrum obtuse, slight notch below antirostrum. Dorsal, ventral, and posterior rims rounded. Sulcus wide and straight; ostium longer than cauda.

Occurrence.—Tuhua, North Island, 1 example; Pukeuri, 7; Awamoa, 9; White Rock River, 1; Ardgowan, 3; Target Gully, 1. Received from Geological Survey of New Zealand and Mr. H. J. Finlay.

Observations.—This species was described by Bassoli in 1906 as *Otolithus (Berycidarum) sulcatus*, following a similar error by Prochazka in 1893 with regard to *O. (Scopelus) pulcher*. Priem pointed out the misdescription in 1911 (4), the sulcus being distinctly scopeloid and in no way resembling that of the Berycidae. *O. (Scopelus) pulcher* has a more prominent rostrum and a more distinct notch than the species now described, which agrees with *O. (Scopelus) sulcatus* described by Bassoli (1) from the Pliocene of Monte Gibio, near Modena, Italy.

Age.—Tertiary (Miocene): Oamaru series.

Otolithus (Scopelus) circularis n. sp. (Plate 61, fig. 2.)

Dimensions.—2½ × 2 mm.

Description.—Circular; outer side domed with radiating lines, inner side flat; notch in ostium; lower line of sulcus with angle between ostium and cauda.

Occurrence.—A single example from Target Gully, received from Mr. H. J. Findlay (type specimen, coll. H. J. Finlay.)

Observations.—This differs in outline and in shape of sulcus from preceding species, also in having radiating furrows on outer side. Priem described in 1911 (4, p. 39) a circular otolith with a distinctly scopeloid sulcus as *O. (Solea) cottreaui* from the Miocene of France, but this had a straighter sulcus than the species now described, which has an outer side unlike any otolith of the Soleidae.

This is without doubt a new species, which I have named *Otolithus (Scopelus) circularis.*

Age.—Tertiary (Miocene): Oamaru series.

Otolithus (Macrurus) gracilis Schubert. (Plate 61, fig. 3.)

Dimensions.—3 × 3 mm.

Description.—Shape roughly circular; outer side with radiations and umbo in centre, inner side flat with radiating ribs above and below sulcus. A deep semicircular depression above sulcus; no rostrum or antirostrum; slight notch above ostium; cauda narrow and depressed.

Occurrence.—A single example from Pukeuri, received from Geological Survey of New Zealand.

Observations.—This species was described by Schubert in 1905 (9, p. 513) from the Tertiaries of Austria-Hungary, and by Bassoli in 1906 (1) from the Pliocene of Monte Gibio, near Modena, Italy.

Age.—Tertiary (Miocene): Oamaru series.

Otolithus (Macrurus) toulai Schubert. (Plate 61, fig. 4.)

Dimensions.—7 × 5½ mm.

Description.—Shape triangular; outer side with longitudinal eminence with radiating furrows extending to rim, forming a serrated edge; inner side convex, smooth. Sulcus extends the length of otolith but does not cut rim. Ostium constricted; cauda narrow with upturned termination.

Occurrence.—Pukeuri, 8 examples; Awamoa, 1; Ardgowan, 2; Target Gully, 2 Received from Geological Survey of New Zealand and Mr. H. J. Finlay.

Observations.—Described by Schubert from the Tertiaries of Austria-Hungary in 1905, and by Bassoli in 1906 from the Pliocene of Monte Gibio, near Modena, Italy. The example figured is a mature specimen, and rather more extended and pointed than the younger examples, which resemble very closely those portrayed by Bassoli, the converging furrows forming a heart-shaped form on the antero-dorsal rim.

Age.—Tertiary (Miocene): Oamaru series.

Otolithus (Physiculus) bicaudatus n. sp. (Plate 61, fig. 5.)

Dimensions.—4½ × 3 mm.

Description.—Shape angular; outer side umbonated and furrowed, inner side flat with depression on dorsal part. There is a prominent dorsal

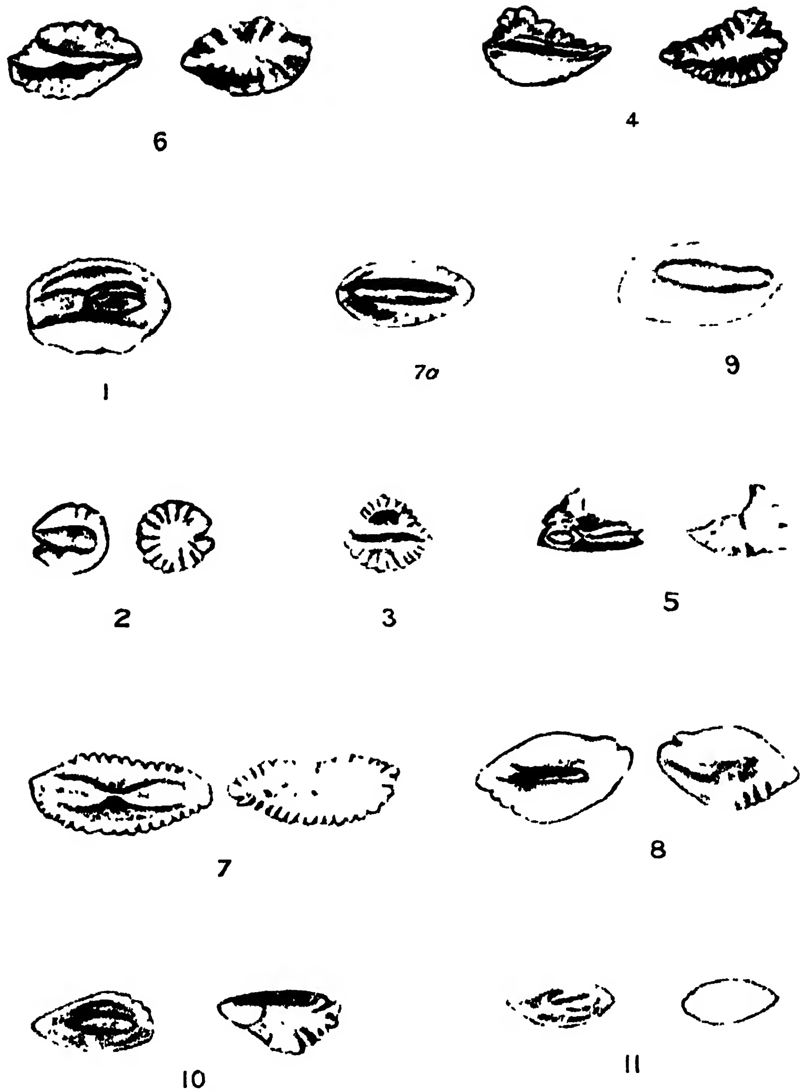

FIG. 1.—*Otolithus (Scopelus) sulcatus* Bassoli. × 4.
FIG. 2.—*Otolithus (Scopelus) circularis* n. sp. × 4.
FIG. 3.—*Otolithus (Macrurus) gracilis* Schubert. × 3½.
FIG. 4.—*Otolithus (Macrurus) toulai* Schubert. × 2.
FIG. 5.—*Otolithus (Physiculus) bicaudatus* n. sp. × 3.
FIG. 6.—*Otolithus (Raniceps) planus* Koken var. *novae-zeelandiae*. × 4.
FIG. 7.—*Otolithus (Merluccius) pukeuriensis* n. sp. × 3.
FIG. 7a.—*Otolithus (Gadus) elegans* var. *sculpta* Koken. × 3.
FIG. 8.—*Otolithus (Ophidium) pantanelli* Bassoli and Schubert. × 3.
FIG. 9.—*Otolithus (Trachinus) mutabilis* Koken. × 5.
FIG. 10.—*Otolithus (Fierasfer) nuntius* Koken. × 4.
FIG. 11.—*Otolithus (Ophidiidarum) elongatus* n. sp. × 4.

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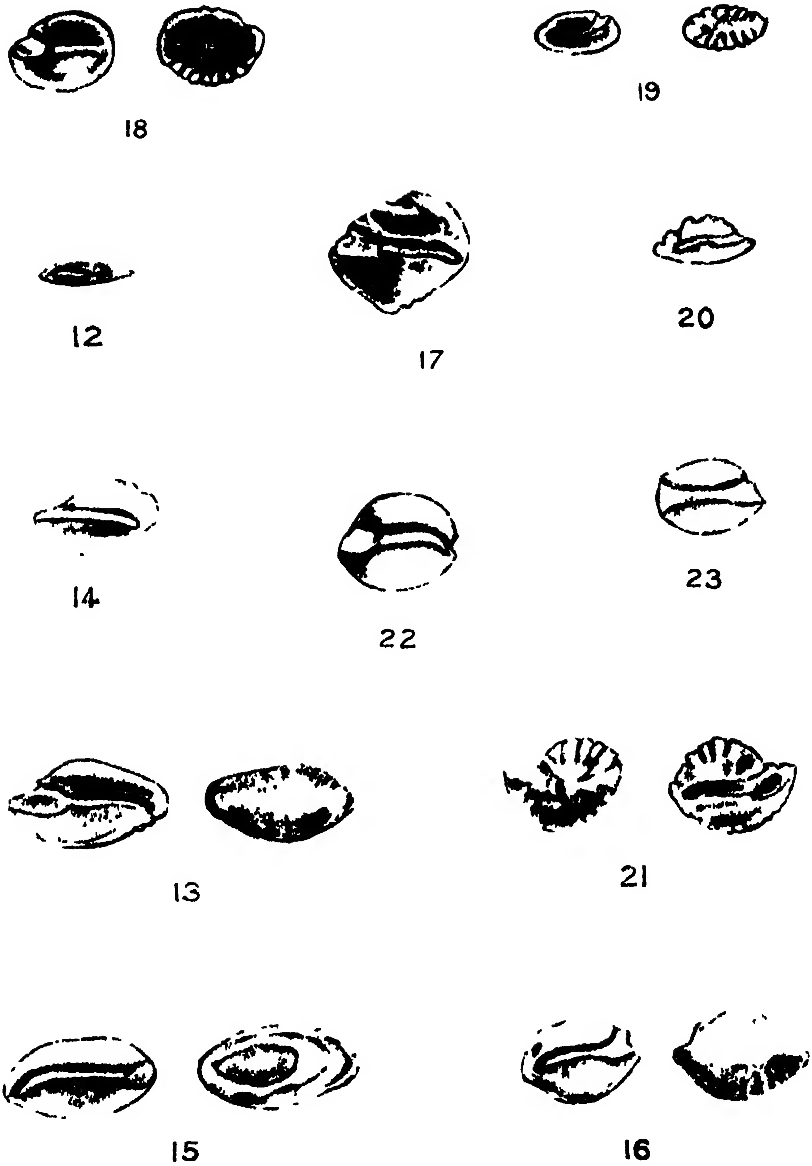

FIG. 12.—*Otolithus (Pleuronectidarum) acuminatus* Koken. × 4.
FIG. 13.—*Otolithus (Serranus) noetlingi* Koken. × 4.
FIG. 14.—*Otolithus (Elops) miocaenicus* n. sp. × 4.
FIG. 15.—*Otolithus (Percidarum) rectus* Priem. × 3.
FIG. 16.—*Otolithus (Sparidarum) elongatus* Priem. × 4.
FIGS. 17, 21.—*Otolithus (Sparidarum) gregarius* Koken. × 4.
FIG. 18.—*Otolithus (Dentex)* aff. *subnobilis* Schubert. × 4.
FIG. 19.—*Otolithus* (inc. sedis) *umbonatus* Koken. × 5.
FIG. 20.—*Otolithus (Parapercis) finlayi* n. sp. × 6.
FIG. 22.—*Otolithus (Percidarum) cottreaui* Priem. × 3.
FIG. 23.—*Otolithus (Citharus) latisulcatus* n. sp. × 5.

process anteriorly, with a backward inclination; frontal rim curved with two indentations, ventral rim curved. Sulcus consists of an oval ostium with colliculum, and a duplicated cauda.

Occurrence. Three examples from Pukeuri, received from Geological Survey of New Zealand. (Type specimen, coll. Geol. Surv. N.Z.)

Observations.—This fossil otolith resembles in a remarkable way the otolith of the living New Zealand species *Physiculus bacchus.* In no other species that has passed through my hands is a double cauda to be seen. The two grooves are equally developed, and both open on the posterior rim, rear of otolith being identical in living and fossil species. Anteriorly they are somewhat different, the oval ostium not being discernible in *Physiculus bacchus* in specimens in my collection, but with further material this may be more apparent. Also, the otolith of living species has an anterior projection which is absent in fossil. In both there is a dorsal horn-like projection, inclined forward in *Physiculus bacchus,* but with a backward inclination in the species now described. The resemblance is unmistakable, and I have therefore called this species *Otolithus (Physiculus) bicaudatus.*

Age. - Tertiary (Miocene): Oamaru series.

Otolithus (Raniceps) planus Koken n. var. novae-zeelandiae. (Plate 61, fig. 6.)

Dimensions.—4 × 3 mm.

Description.—Shape ovate; outer side with radiating furrows, inner side flat; serrated above and below. Sulcus extends across otolith; ostium wide and open; cauda narrow with two constrictions.

Occurrence. A single example from Pukeuri, received from Geological Survey of New Zealand. (Type specimen, coll. Geol. Surv. N.Z.)

Observations. Outer side almost exactly as in *O. (Raniceps) planus* Koken (3, pl. 4) from the Upper Oligocene of Sternberger Gestein; inner side corresponding also with the exception of ostium, which in *O. (Raniceps) planus* is narrow and closed up in front, while in variety now described ostium is wide, and open in front. I have therefore called this *Otolithus (Raniceps) planus* Koken var. *novae-zeelandiae.*

Age. Tertiary (Miocene): Oamaru series.

Otolithus (Merluccius) pukeuriensis n. sp. (Plate 61, fig. 7.)

Dimensions.—7 × 3½ mm.

Description.—Shape long-ovate; outer side concave, inner side convex; serrations on edges. Ostium and cauda equal; constriction in middle of sulcus.

Occurrence. Single example from Pukeuri, received from Mr. H. J. Finlay. (Type specimen, coll. H. J. Finlay.)

Observations. The species described differs from *Otolithus (Merluccius) obtusus* Koken (3, pl. 11) in contour, in concavity of outer side, and also has angle on frontal rim higher. The cauda also approaches nearer posterior rim than in *obtusus.* The front of otolith slopes as in many of the living Gadidae, but in *Merluccius vulgaris* is more rounded, with angle lower. The sulcus is unmistakably that of *Merluccius,* and I have therefore referred this example to a new species *Otolithus (Merluccius) pukeuriensis.*

Age.—Tertiary (Miocene): Oamaru series.

Otolithus (Gadus) elegans Koken var. **scuplta.** (Plate 61, fig. 7*a*.)

Dimensions.—5½ × 3 mm.

Description.—Shape ovate; outer side convex with median ridge and umbo, rim serrated; inner side convex, plain with serrations on edge. Sulcus straight, traverses otolith but does not cut the front or rear edges.

Occurrence.—Single example from Pukeuri, received from Mr. H. J. Finlay.

Observations.—Described by Koken (3, pl. 4) from the Oligocene of Sternberger Gestein.

Age.—Tertiary (Miocene): Oamaru series.

Otolithus (Ophidium) pantanelli Bassoli and Schubert. (Plate 61, fig. 8.)

Dimensions.—6 × 4 mm.

Description.—Shape ovate; outer side convex, smooth with serrations on anterior ventral rim; inner side convex, smooth. Dorsal rim rounded, with fold on posterior angle; ventral rim deep with serrations below the ostium. Sulcus straight; cauda terminates some distance from posterior rim.

Occurrence.—Castlecliff, 1 example; Pukeuri, 4; Ardgowan, 2; Target Gully, 1; Clifden, 1; Waikaia, 5. The Pukeuri specimens were received from Geological Survey of New Zealand, and the others from Mr. H. J. Finlay. (Example figured, coll. H. J. Finlay.)

Observations.—This species was described by Bassoli in 1906 (1, p. 43) from the Pliocene of Monte Gibio and the Miocene of Pantano, Italy. It is very distinctive in shape and in the formation of the sulcus, and appears to range from the Upper Pliocene of Castlecliff, North Island, down to the Oligocene or Miocene of Waikaia, where it is well represented, persisting throughout those Tertiary formations of New Zealand furnishing the material submitted to me.

Age.—Tertiary (Pliocene and Miocene): Oamaru and Wanganui series.

Otolithus (Trachinus) mutabilis Koken. (Plate 61, fig. 9.)

Dimensions.—4 × 2½ mm.

Description.—Shape ovate; outer side concave, inner side convex, front pointed; no rostrum or antirostrum. Sulcus straight; cauda inclined slightly upward.

Occurrence.—One example from Pukeuri, received from Geological Survey of New Zealand; one from Ardgowan, from Mr. H. J. Finlay.

Observations.—The shape of otolith and upward tilt of cauda indicate that this example should be referred to the Trachinidae. The sulcus differs slightly from *Otolithus (Trachinus) mutabilis* described by Koken (2) in 1884 from the Oligocene of Germany and the Miocene of Voeslau, Austria, but the general resemblance is to be seen. Priem (8, p. 274) in 1914 described specimens of this species from the Burdigalien of Martillac, in south-west France, and in one of these the sulcus is nearer that of example now described. I have therefore referred this example to the species described by Koken as *Otolithus (Trachinus) mutabilis*.

Age.—Tertiary (Miocene): Oamaru series.

Otolithus (Fierasfer) nuntius Koken. (Plate 61, fig. 10.)

Dimensions.—3½ × 2 mm.

Description.—Shape ovate; outer side convex, umbonated; inner side flat. Sulcus oval in centre of otolith occupied by colliculum.

Occurrence.—Two examples from Waikaia, received from Mr. H. J. Finlay.

Observations.—This species, which compares well with otoliths of the living *Fierasfar umbratilis*, has been described by Koken (3) from the Oligocene of Soellingen as *Otolithus (Fierasfer) nuntius* Koken.

Age.—Tertiary (Oligocene or Miocene); Oamaru series.

Otolithus (Ophidiidarum) elongatus n. sp. (Plate 61, fig. 11.)

Dimensions.—3 × 2 mm.

Description. Shape ovate with pointed ends, both sides convex. Sulcus short, oblique.

Occurrence.—Single example from Target Gully, received from Mr. H. J. Finlay. (Type specimen, coll. H. J. Finlay.)

Observations.—This species is very similar in outline to that described by Priem (7, p. 157) as *Otolithus (Ophidiidarum)* aff. *kokeni* from the Lutetien of Le Bois-Gouët, Brittany, but the sulcus is different, conforming to that of *Otolithus (Ophidiidarum) pantenelli* Bassoli and Schubert, seen in Plate 61, fig. 8. I have therefore called this *Otolithus (Ophidiidarum) elongatus.*

Age.—Tertiary (Miocene): Oamaru series.

Otolithus (Pleuronectidarum) acuminatus Koken. (Plate 62, fig. 12.)

Dimensions.—3 × 1 mm.

Descriptions.—Shape long with pointed ends, biconvex. Sulcus small, oval.

Occurrence.—Awamoa and Ardgowan, four examples, received from Mr. H. J. Finlay.

Observations.—This species was described by Koken (3) from the middle Oligocene of Waldboeckelheim, and also by Bassoli (1) from the Pliocene of Monte Gibio, Italy.

Age.—Tertiary (Miocene): Oamaru series.

Otolithus (Serranus) noetlingi Koken. (Plate 62, fig. 13.)

Dimensions.—5 × 3 mm.

Description.—Shape ovate; upper rim sloping to rear; outer side concave, inner side convex; ventral rim carinate. Rostrum blunt, antirostrum slight. Ostium wide; cauda longer than ostium, straight, with slight curve downwards at terminations which does not reach posterior rim of otolith.

Occurrence.—Pukeuri and Ardgowan, numerous examples, received from Geological Survey of New Zealand and Mr. H. J. Finlay.

Observations.—The general form and shape of the sulcus are as in the specimens described by Koken (3) from the Upper Oligocene of Sternberger Gestein. Similar otoliths are described by Priem (8) from the Burdigalien of Leognau, France, and referred by him to the above-named species.

Age.—Tertiary (Miocene): Oamaru series.

Otolithus (Elops) miocaenicus n. sp. (Plate 62, fig. 14.)

Dimensions.—4 × 2½ mm.

Description.—Shape ovate; outer side concave, inner side convex; crest of dorsal rim slightly behind middle of otolith; ventral rim carinate with forward projection. Rostrum large, no antirostrum. Sulcus straight, oblique, terminating close to ventral rim but well away from rear of otolith.

Occurrence.—Single example from Pukeuri, received from Geological Survey of New Zealand. (Type specimen, coll. Geol. Surv. N.Z.)

Observations.—This otolith is reproduced in those of the living species *Elops hawaiensis*, the specimens with which I have compared it coming from the Dutch East Indies. It has not been described before, and I have named it *Otolithus (Elops) miocaenicus*.

Age.—Tertiary (Miocene): Oamaru series.

Otolithus (Percidarum) rectus Priem. (Plate 62, fig. 15.)

Dimensions.—6 × 4 mm.

Description.—Shape ovate; outer side concave, showing rings of growth; inner side convex. Sulcus long, with downward curve terminating on posterior rim of otolith. Ostium very small; cauda long.

Occurrence.—Single example from Pukeuri, received from Geological Survey of New Zealand.

Observations.—In looking at the outer side of this otolith one is much inclined to place it among those of the flat fishes: the nearly flat oval form showing the annual rings is the same as in the otoliths of the Pleuronectidae. The sulcus, however, is distinctly of the percoid type; and, although the flat fishes are probably derived from the Percoids, the only species with a similar sulcus is *psettodes*, the other members of the order Heterosomata having a very minute cauda compared with the ostium, while in the species described the cauda is by far the greater. Priem (7, p. 156) has described a similar form of otolith from the Lutetien of Le Bois-Gouët, in Brittany, as *Otolithus (Percidarum) rectus*, and in referring the present example to this species it is worth noting that it apparently forms a link between the otoliths of the Percoids and those of the Heterosomata.

Age.—Tertiary (Miocene): Oamaru series.

Otolithus (Sparidarum) elongatus Priem. (Plate 62, fig. 16.)

Dimensions.—4 × 3 mm.

Description.—Shape elliptical; outer side concave, with radiations on lower part; inner side convex; rostrum blunt, no antirostrum. Ostium wide; cauda curving down and terminating some distance from posterior rim.

Occurrence.—Two examples, from Pukeuri and Target Gully, received from Geological Survey of New Zealand and Mr. H. J. Finlay.

Observations.—This species is longer in proportion to the height than *Otolithus (Sparidarum) gregarius;* otherwise the general appearance is somewhat similar. Described by Priem (6) in 1913 from the Lutetien of Le Bois-Gouët, France.

Age.—Tertiary (Miocene): Oamaru series.

Otolithus (Sparidarum) gregarius Koken. (Plate 62, figs. 17, 21.)

Dimensions.—4½ × 4 mm.

Description.—Shape roughly circular; outer side concave with umbo, inner side convex; dorsal rim rounded posteriorly, ventral rim carinate. Rostrum blunt, no antirostrum. Ostium wide; cauda narrow and curved downward.

Occurrence.—Three examples from Waikaia and Clifden, received from Mr. H. J. Finlay.

Observations.—Described by Koken (3) from the Upper Oligocene of Sternberger Gestein; also by Priem (8) from the Burdigalien of south-west France.

Age.—Tertiary (Oligocene or Lower Miocene): Oamaru series.

Otolithus (Dentex) aff. subnobilis Schubert. (Plate 62, fig. 18.)

Dimensions.—3½ × 2½ mm.

Description.—Shape elliptical; outer side concave with radiating furrows to ventral rim, and oblique groove on anterior part of dorsal rim; inner side flat. Sulcus straight, ostium wide, upward inclination. Cauda wide with open termination; does not extend to posterior rim.

Occurrence.—Three examples, from Waikaia, Ardgowan, and Pukeuri, received from Geological Survey of New Zealand and Mr. H. J. Finlay.

Observations.—Described by Schubert in 1906 (10) from the Tertiaries of Austria-Hungary, and by Priem (8 p. 264) in 1914 from the Burdigalien of Leognan, south-west France.

Age.—Tertiary (Miocene): Oamaru series.

Otolithus (inc. sedis) umbonatus Koken. (Plate 62, fig. 19.)

Dimensions.—2 × 1 mm.

Description.—Shape ovate, biconvex; outer side umbonated. Sulcus narrow, oblique with ostium on dorsal rim.

Occurrence.—Two examples, from Waikaia and White Rock River, received from Mr. H. J. Finlay.

Observations.—Described by Koken (2) from the Oligocene of Lattorf, Söllingen, Antwerp, and other places.

Age.—Tertiary (Miocene): Oamaru series.

Otolithus (Parapercis) finlayi n. sp. (Plate 62, fig. 20.)

Dimensions.—2 × 1 mm.

Description.—Outer side convex, umbonated; inner side flat; dorsal rim serrated, and sloping equally to front and rear of otolith; ventral rim crescentic. Sulcus oblique; ostium and cauda of equal length. Cauda terminates some distance from rear of otolith.

Occurrence.—Single example from Wharekuri, received from Mr. H. J. Finlay. (Type specimen, coll. H. J. Finlay.)

Observations.—This solitary and minute example is of a distinctive percoid type. I find that it most resembles the otoliths of the so-called "blue cod" of New Zealand (*Parapercis colias*), and have therefore named it *Otolithus (Parapercis) finlayi*, after Mr. H. J. Finlay, to whom I am indebted for sending the specimen.

Age.—Tertiary (Oligocene): Oamaru series.

Otolithus (Percidarum) cottreaui Priem. (Plate 62, fig. 22.)

Dimensions.—5 × 4 mm.

Description.—Shape circular; outer side flat, inner side convex; indentation in posterior rim. Sulcus broad; ostium depressed, wide. Cauda wide, curved downward, termination close to posterior rim.

Occurrence.—Single example from Pukeuri, received from Mr. H. J. Finlay.

Observations.—This was described by Priem in 1912 (5, p. 247) from the Eocene of Le Bois-Gouët, of south-west France. The example from Pukeuri differs in having the notch on posterior rim, but otherwise the resemblance is sufficient for identification.

Age.—Tertiary (Miocene): Oamaru series.

Otolithus (Citharus) latisulcatus n. sp. (Plate 62, fig. 23.)

Dimensions.—2½ × 2 mm.

Description.—Shape ovate; outer side convex, inner side slightly convex; dorsal and ventral rims rounded; angle between dorsal and posterior rim. Rostrum pointed, no antirostrum or notch. Sulcus very wide; cauda opening widely on posterior rim.

Occurrence.—A single example from Pukeuri, received from Mr. H. J. Finlay. (Type specimen, coll. H. J. Finlay.)

Observations. On comparing this specimen with the otoliths of the living *Citharus linguatula* the resemblance is at once apparent. Bassoli (1) describes a fossil *Citharus* otolith from the Pliocene of Monte Gibio—*Otolithus (Citharus) schuberti*; but in this species the cauda is narrower and does not widen out on the posterior rim as in the example now described. The outline also is different. We have here a new species, which I have named *Otolithus (Citharus) latisulcatus.*

Age.—Tertiary (Miocene): Awamoa series.

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Two Fossil Cephalopods from North Canterbury.

By P. MARSHALL, M.A., D.Sc., F.G.S., F.N.Z.Inst., Hutton and Hector Medallist.

[*Read before the Philosophical Institute of Canterbury, 5th December, 1923; received by Editor, 24th December, 1923; issued separately, 28th August, 1924.*]

Plates 63, 64.

PROFESSOR R. SPEIGHT has been good enough to give me two fossil specimens, recently found in the Hurunui country, for identification and description. One of them was found in the Hurunui River bed near Ethelton, and its origin is unknown so far as exact site is concerned.

This specimen is an ammonite quite different from any species that has previously been found in New Zealand. A description of it is given below.

DALMASICERAS Djanélidzé, 1922.

A full description of this genus is given by its author (256–62, *Bull. G.S. de France*, ser. 4, vol. 21, 1923). The following is an abridged statement:—

Whorls in adult form very flattened, but innermost whorls wider than high. There are usually umbilical tubercles except in very young or very old forms. In some forms ribs may be fasciculated from umbilical tubercles. Usually there are primary ribs which originate on umbilical slope or on tubercles. About half-way along flank secondary ribs arise, two or three in number, between each pair of primary ribs. Suture-line is specially characterized by the short siphonal lobe, by a suspensive (umbilical) lobe formed from the summit of the second lateral saddle with its secondary lobe and the auxiliary lobes. First lateral lobe very large and unsymmetrical; of its two lateral branches the external is the larger. The lobes and saddles are long and straight. The summit of the principal saddles is symmetrically divided by a secondary lobe. The antisiphuncular lobe is straight, deep, and impaired. The genus is apparently restricted to the Upper Tithonian.

Dalmasiceras speighti n. sp. (Plate 63, figs. 2, 3; Plate 64, figs. 1, 2.)

The shell is of moderate size, but is too imperfect for exact measurement at a greater diameter than 51 mm. Its dimensions (in millimetres) are—

				A.
Diameter ..	51	100	85	
Height ..	23	45	35	41
Width ..	13·5	26	17	20
Umbilicus ..	17	33	26	31

It is thus not very different in form from *D. kiliani* Djanélidzé, though distinctly wider and lower, a difference that might well be due to the larger size of the latter specimen. The involution is about one-half, whorls

much higher than wide, with the greatest width near the umbilicus. Wall of the umbilicus steep but very soon sloping off into the flank, which is gently inclined towards the sharply-curved periphery.

Ornamentation: Strong rounded primary ribs begin at bottom of umbilicus. They are first sharply curved backwards but afterwards cross flanks radially. Near periphery they bend forward and end with sharp forward curve near siphuncle. These ribs sometimes fork at about a third of their length from umbilicus. On border of periphery one or two secondary ribs are inserted between each pair of primary tibs. There are occasional constrictions on inner whorls.

The suture-line is almost identical with that of *Dal. dalmasi* (Djanélidzé, *l.c.*, fig. 3, p. 267) in particular, the short external lobe and the long and wide important first lateral lobe, which is not symmetrical. The other lobes also are very similar. The saddles are nearly equally divided by a secondary lobe, and show much the same state of division as those of *Dal. dalmasi*. The internal lobe, however, is rather different. The large anti-siphuncular saddle has not quite the same importance as in *Dal. dalmasi*, and the umbilical or suspensive lobe is not quite so deep.

It is interesting to record such an ammonite as this from New Zealand, as, judging from European equivalents, the horizon at which this species occurs is the Upper Tithonian. It is to be hoped that before long the locality from which the specimen came will be found, when it is possible that other members of the fauna of the period may also be collected.

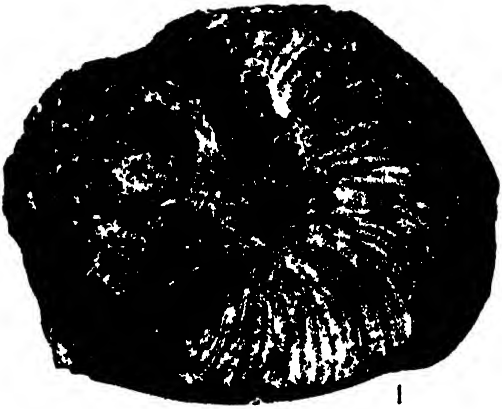
Nautilus Linné.

The second specimen, Professor Speight tells me, was found at the Kaiwara Creek in a calcareous gritty greensand which here forms the base of the series of Cretaceous and Tertiary rocks; these, as usual, rest with a high unconformity on middle or older Mesozoic rocks. This specimen, though somewhat crushed, can be identified with certainty as a species of *Nautilus*.

Nautilus sp. aff. **suciensis** Whiteaves. (Plate 63, fig. 1.)

The specimen is 120 mm. in diameter and 80 mm. wide. Ventral surface is broadly rounded, and umbilicus appears to be completely covered. Surface ornamented with a series of large ribs continuous from umbilicus to periphery. At umbilicus ribs are nearly radial; they soon bend forwards, but at shoulder bend in a gentle curve strongly backwards and pass over periphery with backward loop. The condition of the specimen does not allow the position of the siphuncle to be seen.

These broadly-ribbed species of *Nautilus* do not appear to have existed after the Cretaceous period. The species *N. suciensis* Whiteaves, to which the present specimen is clearly closely allied, comes from Skidegate Inlet, in British Columbia, in rocks of Senonian age. No species of this group of *Nautilus* has previously been recorded from New Zealand.



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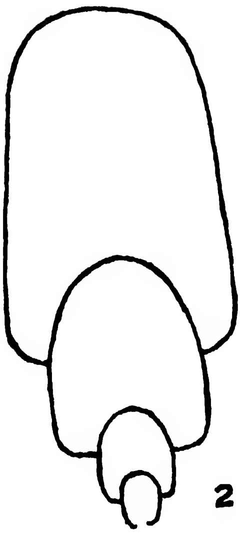

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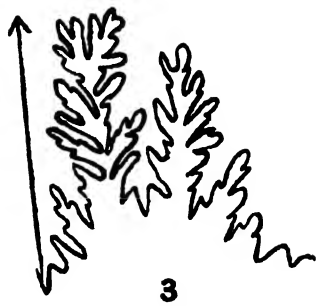

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FIG. 1.—*Nautilus* aff. *suciensis* Whiteaves. × ½.
FIG. 2.—*Dalmasiceras speighti*: Cross-section. × 2.
FIG. 3.—*Dalmasiceras speighti*: Internal suture line.

1.

2

Fig. 1.—*Dalmasiceras speighti* n. sp. Natural size.
Fig. 2.—*Dalmasiceras speighti* n. sp: Suture-line. At diameter, 71 mm.; height, 24 mm.; width, 15 mm.

*The "Hydraulic Limestones" of North Auckland.**

By P. MARSHALL, M.A., D.Sc., F.G.S., F.N.Z.Inst., Hutton and Hector Medallist.

[*Read before the Philosophical Institute of Canterbury, 5th December, 1923; received by Editor, 24th December, 1923; issued separately, 28th August, 1924.*]

A CONSIDERABLE amount of discussion has taken place in regard to the age of this formation. It is not intended in this paper to review the opinions that have been expressed in regard to this question, and it will merely be stated that the officers of the Geological Survey regard it as of Cretaceous age, whilst in various papers the present author has ascribed to it a Lower Tertiary age. At the present time it is merely intended to mention some facts not previously adduced which favour the author's contention.

The "hydraulic limestone" is, generally speaking, a foraminiferal limestone which covers large areas of the North Auckland Peninsula between Hokianga and Waipu, thence extending south-westward to the Kaipara Harbour. Although usually composed largely of the tests of Foraminifera, it frequently contains also a great many remains of organisms that had siliceous skeletons—sponges, diatoms, and Radiolaria are included amongst these. The limestone often contains a good deal of glauconite, and sometimes a number of grains of silica. Although relatively hard, it is traversed by a great number of crevices and joints, and slides readily, even on country with gently sloping relief. It has been subject to considerable earth-pressure, and is usually intensely folded, and sometimes also faulted. Up to the present time no fossils that indicate a definite age have been recorded from it. In the Auckland Exhibition of 1912 a *Cucullaea* and a *Dentalium* were shown in a case by the Wilson's Cement Company. These specimens, however, have never been described, and appear now to be lost. Some stratigraphical relations have lately been noted and require a definite statement.

(1.) At Pahi the hydraulic limestone is clearly seen to overlie a greensand. This is very clear on the shore-line of the eastern side of the Pahi arm of the Kaipara Harbour, between Whakapirau and Jackman's, where the rocks dip about 30° to the south-west and strike to the north-west.

(2.) On the hill between Pahi Township and the Arapaoa arm of the Kaipara Harbour it is found that all the eastern and higher parts of the hill are formed of limestone, while greensands crop out at the bottom of the western and southern sides. On the west side and on the south the greensands have a generally easterly dip. The obvious conclusion is that the greensands dip under the hydraulic limestone. Although the slope of the hill near the base is covered with detritus, the dip of the rocks shows that their relation is properly represented by the diagram fig. 1—the same relation as at Jackman's, mentioned previously, which is about one mile distant.

If the shore-line of the Arapaoa arm is followed to the north-west for about one mile, a syncline is found exposed on the foreshore of the harbour

* For a map of the locality see MARSHALL, *Trans. N.Z. Inst.*, vol. 49, p. 435, 1916.

and cliff that bounds it, as shown in fig. 2. At the south-east side of this syncline there has been a small amount of differential rock-movement, and the limestone has moved slightly over the greensand. There has been no movement of this kind at the north-west side, and there the limestone shows gradations to the greensand.

At a third point, between Mr. Blackwell's house and Tokatapu, opposite Colbeck's Landing, on the west side of the Pahi arm, the hydraulic limestone is again seen to rest on a highly arenaceous greensand, which is probably a local equivalent of the Pahi greensand. Again at Portland, near Whangarei, about fifty miles distant, on the downthrow side of a fault which shows clearly in a cutting on the railway-line, the greensand has been lowered so as to be brought into contact with the limestone. In these four localities it is clear that the hydraulic limestone is a higher horizon than the greensand.

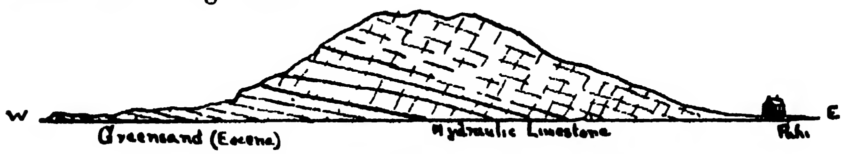


FIG. 1.—Hydraulic limestone between Pahi and Arapaoa arm.

Palaeontological evidence of the age of the limestone is very scanty. The greensand which lies below it at Pahi contains a considerable variety of fossil Mollusca, including an *Aturia*, and is probably the equivalent of the European Eocene certainly not Cretaceous. It follows that the hydraulic limestone in this locality at least is not older than the Upper Eocene.

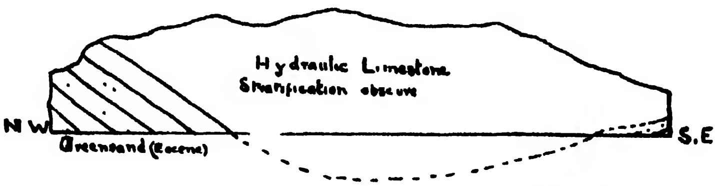


FIG. 2.—Syncline on foreshore north-west of Arapaoa arm.

Mr. W. Linton, of Batley, recently presented to the Auckland Museum a shark's tooth obtained from the hydraulic limestone near Batley, about six miles from Pahi. Dr. Smith Woodward, of the Natural History Branch of the British Museum, kindly examined it for me, and wrote as follows: "The green tooth of *Carcharodon* from Batley has the irregular serrations which characterize our Eocene and perhaps Danian species. To me it suggests Eocene age. The base being absent, it cannot be determined specifically." Miss Rhoda Linton also found a large vertebra near the same locality. Dr. Smith Woodward wrote of this: "The vertebra belongs to a large Lamnid shark, perhaps *Carcharodon*.

There is also in the Auckland Museum a string of six similar vertebrae from the hydraulic limestone at Portland, and, like the previous one, these probably represent *Carcharodon*.

This palaeontological and stratigraphical evidence seems to me to prove that the hydraulic limestone at Portland, Pahi, and Batley is certainly of Tertiary age, and not older than the Upper Eocene.

The Benmore Coal Area of the Malvern Hills.

By R. Speight, M.A., M.Sc., F.G.S., F.N.Z.Inst., Curator of the Canterbury Museum.

[*Read before the Philosophical Institute of Canterbury, 7th November, 1923; received by Editor, 24th December, 1923; issued separately, 28th August, 1924.*]

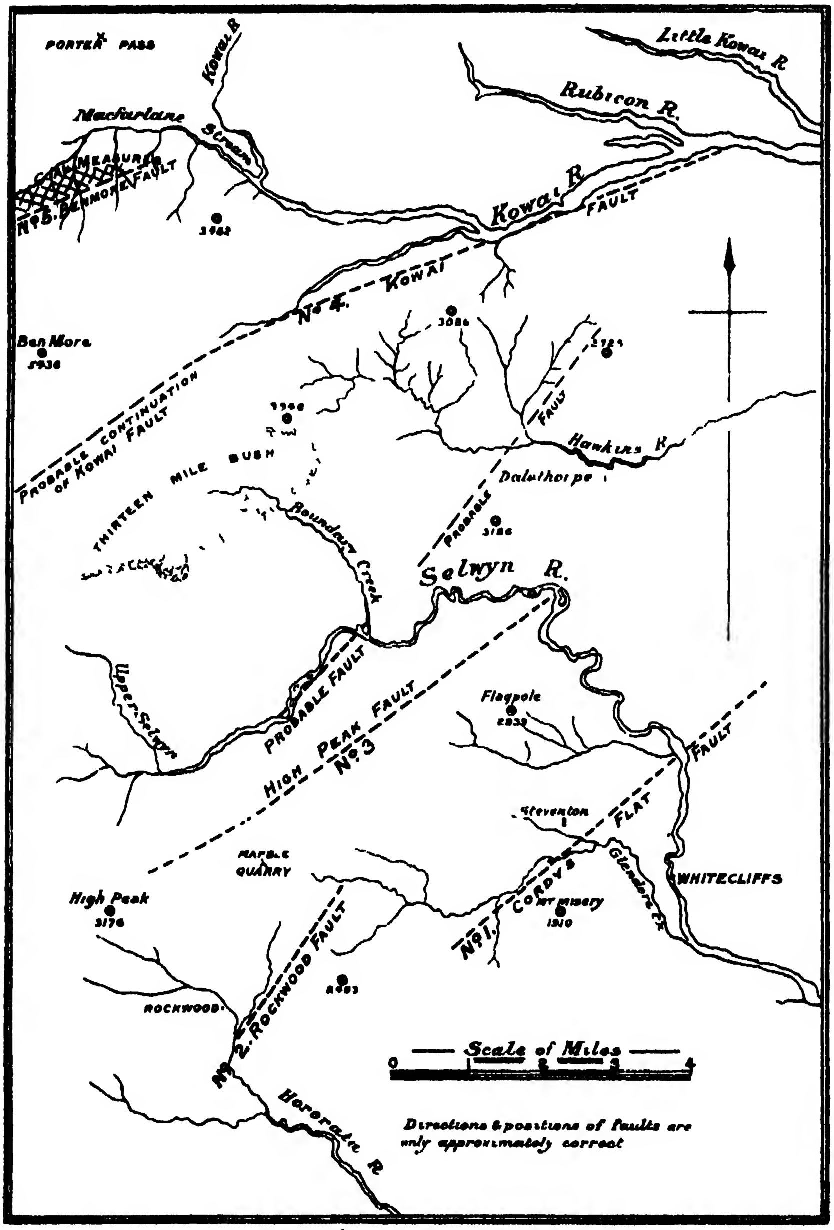
The Benmore outlier of the Malvern Cretaceous series was described in some detail by Haast (*Report of the Geol. Explor. during 1871–72*, pp. 41–46, 1872), special attention being given to it, since it was looked on as a possible source of coal. Some development work was carried out, but it was soon discontinued, chiefly on account of the inaccessibility of the area, the poor character of the coal, and the probable amount available not warranting any further exploitation. Recent examinations of the area by the present author have revealed geological features of some interest, notably in their bearing on the origin of the present topography of the Malvern Hills and of the Southern Alps, and hence this brief account.

The extent of country covered by this outlier is about a mile in length, with a width varying from nothing at its two ends up to about half a mile in its widest part, which occurs near the middle of the area. The height above sea-level varies from about 2,000 ft. to just over 3,000 ft., so that it is one of the highest occurrences of coal-measures in the alpine region of the South Island. Some few are certainly higher, but they are by no means so extensive. It is located in the valley of Macfarlane Stream, which is a tributary of the Kowai River, and lies immediately south of Porter Pass (see map), in that gap which divides the Big Ben and Mount Torlesse Ranges, on a kind of shelf on the north side of Benmore, the highest point of the former range. This shelf has a general N.E.-S.W. trend, but it is divided from the valley of Macfarlane Stream for the north-eastern half of its length by a barrier of greywacke, the difference in elevation of the outlier above the bed of the stream at this end being about 800 ft. On following it towards the south-west the beds occur at stream-level, nearly all the drainage of the area converging to a point about half-way along its northern side. From the shelf just referred to the slopes of Benmore rise steeply for another 1,500 ft., the change in surface-features on passing from coal-measures to greywacke being most marked. The coal-measures rest unconformably on the greywackes, the slope of the basement beds being continued to the north-west as a well-preserved stripped surface, whereas on the south-east side the area is bounded by a fault whose features will be detailed later.

The chief tributaries of Macfarlane Stream rise in the northern slopes of Benmore, and run in approximately north-western directions in sub-parallel channels incised in their lower reaches into the easily eroded coal-measures. As these channels enable a clear insight to be obtained into the structure of the area, a description of the beds occurring in each will be given.

The extreme north-eastern end of the area consists of clays, sandy clays, and thin beds of lignite most of which is of low grade. This part is much disturbed by slip and covered with surface debris, so that it is impossible to obtain a definite idea of the relations of the various beds. The first

clear section is obtained in the bed of the creek farthest north-east. This rises in Benmore and cuts the coal-measures—the upper portion almost on



Sketch Map of
MALVERN HILLS SHOWING MAIN FAULT LINES

the line of strike, and the lower part more in the direction of the dip. Haast enumerates in detail the beds occurring in the lower part of the

series, and the following is a summary of his record (see Section 1, although this is intended for the creek farther west) :—

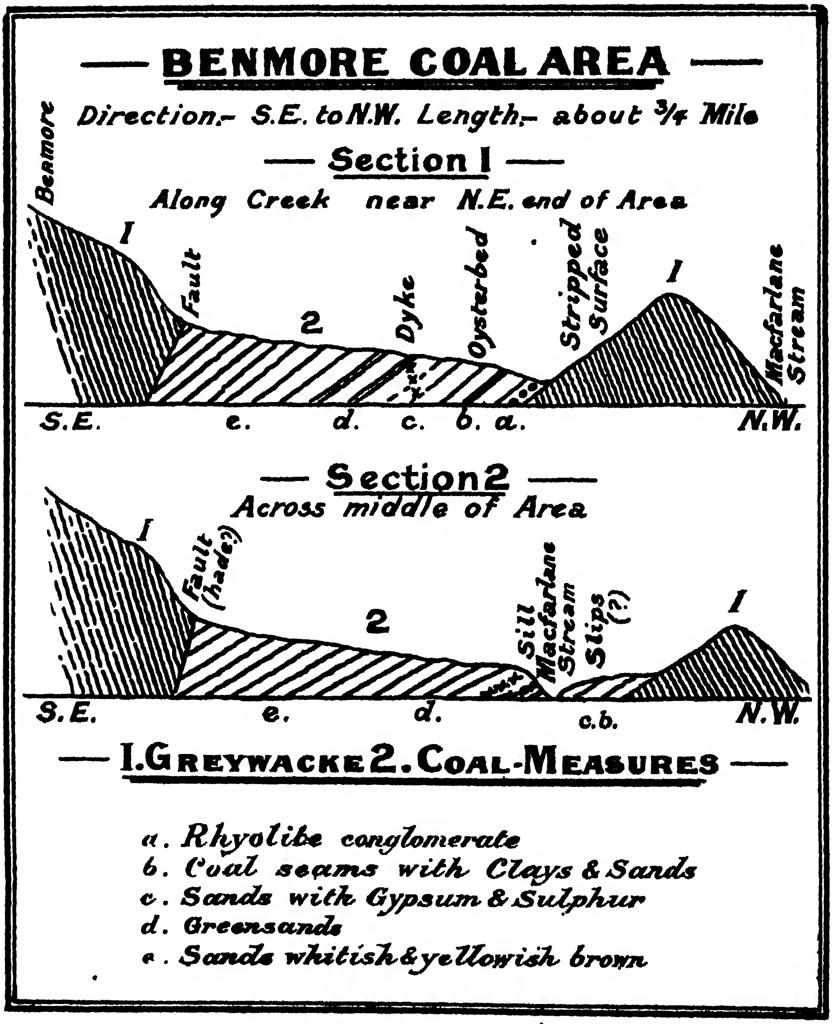
1. Shales and porphyry conglomerate	60 ft. to 80 ft.
2. Bluish sandy clays	15 ft.
3. Brown coal	11 in.
4. Ferruginous and white quartzose sands alternating	11 ft.
5. Clays, shales, sandy clays, and brown coal in small seams	7 ft.
6. Brown coal, main seam	4 ft. 7 in.
7. Shales, clays, and sands, with occasional layers of brown coal	110 ft. (approx.)
8. Oyster-beds with intercalated clay	6 ft.
9. Sands and shales interstratified, the former yellowish-green or greyish weathering pink and brown, with smell of H_2S, and crystals of gypsum	60 ft.

The uppermost beds exposed in this creek strike N. 10° W., and dip south-west at angles approximating 20°, but the lower beds swing round till they strike more to the north-west. At the top of the exposure the beds are much disturbed, slickensided, crushed, and apparently overturned along a line of fault, as if the greywackes had been thrust against them from the south-east. The two important beds in the series are the porphyry conglomerate, about which more will be said later, and the oyster-bed, which contains *Ostrea dichotoma* like that in the Glentunnel area of the Malvern Hills, and definitely correlates the two occurrences as being of the same age.

The bed called by Haast a "porphyry conglomerate" is a conglomerate with a fine-grained matrix in which are pebbles of a rhyolite similar to that occurring on the ridge extending from Mount Misery, through the Rockwood Range, to Rakaia Gorge. The pebbles are small, the largest seen measuring about 2 in. in length, very well rounded, flattish, with characteristic shingle shape suggesting long wear on a beach. Allowing for the smaller size of the pebbles, the conglomerate is similar to that which occurs elsewhere in the Malvern Hills at the base of the Cretaceous series, notably at Rakaia Gorge, White Cliffs, and on the south-eastern slope of Mount Misery; and its occurrence at Benmore is somewhat remarkable, since the nearest rhyolites in position are in the neighbourhood of High Peak, on the Upper Selwyn, nine miles away in a straight line, whereas Mount Misery is twelve miles distant. A similar conglomerate occurs in the basin of the Kowai at the bridge over the river, where there is a small exposure of coal-measures, this being the nearest recorded occurrence of a bed similar to that occurring at Benmore. It should be noted, however, that Hutton mentions the occurrence of a pebble of rhyolite in a conglomerate in the coal-measures at Craigieburn, near Lake Pearson ("The Geology of the Trelissick or Broken River Basin, Selwyn County," *Trans. N.Z. Inst.*, vol. 19, pp. 398-99, 1887), and discusses its bearing on the form of the land when the beds were laid down. This pebble is in a collection at the Canterbury Museum, and Hutton's determination can be confirmed.

A few chains to the north-west of this creek is another coming in from the slopes of Benmore, but in this the sequence cannot be seen as clearly (see Section 1). The rhyolite conglomerate occurs at the base, resting on

the greywacke, and this is succeeded by shales and sands with coal. After some intermission where the outcrops are quite hidden by surface accumulations, there are exposures on the western side of the gully which the stream has worn, consisting of concretionary sands, well bedded, with layers of harder and softer material interstratified with sandy shales; some of the harder layers contain numerous sharks' teeth. These beds strike N. 10° W., and dip to the west at angles of 15°. They are succeeded by



greensands, containing rounded concretions and hard concretionary layers of greensand, and these pass up into grey quartzose sands, light-green sands, and whitish sands, which close the sequence here. The topmost beds lie faulted against the greywacke, which has been pushed over the sands from the south-east. The fault-plane hades at an angle of 40°, and apparently runs north-east and south-west. The surface of the sand is indurated and much slickensided. It is impossible to determine the amount of the throw from the exposures.

On the western side of this gully three basic dykes occur. The most easterly of these is exposed in a face consisting of hard and soft sandstones. It is about 5 ft. wide, and strikes N. 5° E. A narrow band of altered material lies alongside the dyke. This appears to be the one referred to by Haast (*loc. cit.*, p. 45). Two other dykes also occur on the crest of the ridge dividing the basin of this creek from the next one lying to the west. These dykes may be part of one main intrusion, but as they appear on the surface they are quite distinct, and sands are exposed on the ground between them. One forms a small wall for a short distance, which runs N. 15° E., but the other is not defined where exposed, although the slopes to the westward are covered with detached blocks over a considerable area. They have both been intruded into sands.

The rock of which these dykes are formed is a very basic basalt. In a groundmass composed of feldspar laths, augite granules, and rather long individuals of magnetite with the skeletal outline of ilmenite, there are many phenocrysts of olivine and augite, the former predominating in number. Some of these show signs of serpentinization, but they are usually fresh and colourless, or with cracks stained with oxide of iron. They, as well as the augite, frequently form aggregations. The rock does not show any close relation to the teschenitic varieties which occur at High Peak and at Rakaia Gorge, but is more closely connected with the basic rocks of the other areas of the Malvern Hills.

The next creek to the west is the main source of Macfarlane Stream (see Section 2). On the north-west boundary of the outlier clays and shales with coal lie on the greywacke, but the country is much slipped. These beds are succeeded by sands and greensands, well exposed in a gully coming in from the north, and also in a tributary coming in from Benmore on the south. The line of the former has been determined by a basaltic intrusion. On its south-east side shales at times carbonaceous, sandy shales with gypsum crystals and greensands, and sands with concretionary bands are exposed, striking north-east and dipping south-east at angles of from 35° to 40°. In the tributary from Benmore there are sands of varying colour—grey, brown with oxdized iron, green with glauconite, and yellowish-white passing into white—all dipping south-east at an angle of 30°, the whole thickness of the coal-measures in this part of the area being approximately 1,500 ft. These sedimentaries are intruded by a massive basalt sill. Where exposed in Macfarlane Stream it is 50 ft. thick, but it thins out when traced along the gully to the north, and does not appear on the surface on the north-west boundary of the area. It can be traced across country to the west of the main creek, and appears in a creek coming from a saddle in the extreme south-west corner of the basin. Although Haast looked on this occurrence of igneous rock as a surface flow, there is little doubt that it is an intrusion in the form of a sill. The following points are of importance in this connection: (1.) The contacts of both the upper and lower surfaces are intrusive contacts, the beds both above and below the mass being affected by its heat. (2.) It is not parallel to the stratification, but crosses it at a small angle.

Haast evidently thought that all these igneous occurrences belonged to one great sheet, but the evidence clearly points to their discontinuity on the surface.

Where the tributary creek from Benmore crosses the boundary of the coal-measures there is decided evidence of faulting on a large scale. No actual contacts can be seen, owing to debris slopes coming from the

greywacke, but on the line of the fault the greywacke is exposed some 250 ft. to 300 ft. vertically above the line to which the coal-measures reach in the bed of the creek, and the fault-plane is in consequence almost vertical, if not actually in a reversed position.

The chief tributary of Macfarlane Stream farther west follows the strike approximately, but in the gullies coming in from the flanks of Benmore the upper sand and greensand beds are exposed in places, and the position of the south-east boundary suggests the continuance of the fault-line to the south-west. The width of the coal-measures narrows gradually on tracing them south-west, but they extend almost to the crest of the saddle at the head of the creek. In this creek the sill mentioned previously occurs about 250 yards above the junction, strikes nearly due east, and dips south at an angle of 40°. It underlies light-green sands. Immediately up-stream from it a gully comes in from the south, in which are exposed greensands with rusty-brown stain, grey sands, sandy shales, passing up into greenish and greyish sands, which are brownish and yellowish near the fault-line. These beds dip south-east 50°.

No decided conclusion can be come to as to whether the area was glaciated or not. There is no reason why ice should not have invaded the head of the basin of Macfarlane Stream over the saddle which leads to the Rakaia Valley, especially as there is undoubted proof of the presence of glacier-ice lower down the Rakaia Valley having crossed ridges at a higher elevation than this saddle, and some of the features in the upper part of the basin can be attributed to ice-action. In the middle of the basin there are numerous large blocks of greywacke scattered over the surface, which suggest from their size and position that they have been carried by ice; but there is a possibility—perhaps a remote one—that they have been shed from the slopes of Benmore at a time antecedent to the dissection of the weak Cretaceous beds on which they now lie, and it is just possible, though not probable, that they have been transported by agencies other than ice.

The two special features of the area which have an interest not limited to the area itself are the occurrence of rhyolite conglomerate and also the positive evidence of faulting. With regard to the former, Hutton noted a difficulty, especially in the occurrence of the rhyolite pebbles at Craigieburn, and attributed its wide distribution to the action of a hypothetical river running from the Malvern Hills, past Benmore, through the Broken River basin, but he considered the form of the land-surface to be substantially the same as that at present existing. If, however, we take a more modern interpretation of the origin of the alpine region of Canterbury, with a stage during the middle Cretaceous after Jurassic folding, when it was reduced to a peneplain, then the features present no difficulty. The rhyolite pebbles have in that case travelled up a shore-line from their place of origin in the neighbourhood of the Misery–Rockwood ridge, or perhaps from farther out in the plains from an area of rhyolite now buried under Tertiary and Quaternary deposits.

When this peneplain, with its cover of sediments, was raised at the close of the Tertiary era the elevation was attended with faulting, and it is probable that this faulting continued down to a comparatively late recent date. In any case, this faulting is responsible for the major surface features of the Malvern Hills as they stand at present. From a study of the lie of the remnants of the Cretaceous coal-bearing beds which are preserved in the valleys in the heart of the Malvern Hills a

well-defined series of subparallel faults may be inferred. These are as follow (see maps):—

(1.) *The faulted area where occurs the Cordy Flat Coalfield*, now being worked at Steventon. The fault-line runs along the northern flank of the Cairn Range, and continues in a south-west direction along the northern side of Mount Misery.

(2.) *The area about Rockwood Station*, whose position is determined by a fault which follows up the eastern side of the eastern branch of the Hororata River towards Phillips Saddle, and may be continued through it, since small patches of coal-measures occur on the north-eastern flank of Rocky Peak, and the form of the saddle suggests a structural origin.

(3.) *The Upper Selwyn basin*, which is faulted down along the north side of the Flagpole Range on a line running past High Peak. A splinter of this fault probably occurs a little to the north-west, and this continues to the north-east into the basin of the Hawkins River behind Dalethorpe, where the well-marked stripped surface indicates a former extension of the coal-measures into the upper basin of that stream, the only visible surviving remnant being a small patch on a tributary coming in from the north just west of the trig. marked 2725. The stripped surface of the Hawkins area is a continuation of that of the Upper Selwyn area, since there is no break between the basins of the two streams, and the upper Selwyn River may at one time have flowed into the Hawkins.

(4.) *The basin of the Kowai west of Springfield*, where the fault-line runs along the base of the Russell Range, the fault-line or fault-line scarp being strongly indicated by the series of faceted spurs fronting the Kowai River. The line of fault runs in close to the small patch of exposed coal-measures near the Kowai Bridge, which are crushed and much disturbed stratigraphically, while the hill slopes opposite on the lower spurs of Mount Torlesse are a stripped surface, which continues across the Waimakariri on to the downs behind the Woodstock Station, the greensands and underlying beds containing *Conchothyra* and *Trigonia*, and other shells exposed in the bed of the river near Otarama being a part of the beds which have been faulted down.

These problematical coal-measures have been covered up by the aggrading gravels brought down by the Kowai and its tributaries. An extension of this fault-line probably follows after a slight turn along the south-eastern flank of the Benmore Range. The marked break in the topography all along the range, and the similarity in the form of successive ridges as they abut against the sides of Benmore, are to be explained in this way, although there hardly appears to be sufficient evidence on which to base a positive statement of the existence of a fault. Its direction is nearly parallel with what may be regarded as definite fault-lines occurring in other parts of the area.

This suggested fault would necessitate a change of throw from the north-west to the south-east side of the fault, a reversal of displacement amounting to hundreds, if not to thousands, of feet. Such a change would be remarkable in a short distance. For these reasons the continuance of the Kowai fault along the south-eastern flank of the Benmore Range is somewhat doubtful.

(5.) *The Benmore area*, described previously. If the suggested explanation of the origin of this area be correct, it is probable that the gap between the Big Ben Range and Mount Torlesse, through which passes the West Coast Road over Porter Pass, has been determined by faulting, and also

that this fault-line, or a closely related one, may cross the Rakaia River above the junction of the Acheron, and account for the position of the Redcliff limestone-beds, with their underlying sands, these limestone-beds representing a deeper-water deposit as the sea transgressed over the area during mid-Tertiary times after the coal-measures had been laid down. In my paper on Redcliff Gully (*Trans. N.Z. Inst.*, vol. 45, pp. 340–41, 1913) I had considered the possibility of the beds occurring there being connected with the limestones in the Broken River basin, and had decided against it. I do think, however, that they may be connected with the coal-measures of the Benmore area, and both may be remnants of a more widely distributed covering-sheet of Tertiary sediments.

The lines of fault indicated above are, with the exception of No. 2, thoroughly well authenticated, and No. 2 is probably correct. Their downthrow side lies to the north-west, but there is not sufficient evidence to show whether the faults are normal or reversed. The Benmore fault is certainly overthrust to the north-west, but faulting occurs at Rakaia Gorge where the overthrusting is to the south-east. Judging from the inclination of the beds and the separation of the outcrops of similar beds, the throw in certain cases amounts to thousands of feet, but with wide stretches, where no remnants of the covering beds occur, it is unsafe to determine throws from observations of dip and distance merely. Possible folding or change in the inclination of the strata forming the cover, even on a gentle scale, would render such calculations absolutely unreliable. A variation in the amount of vertical displacement along the line must also be expected.

This system of faulting on subparallel lines results in the Malvern Hills and the country behind them having a surface characterized by subparallel ridges, which have a general N.E.-S.W. trend, parallel to the main lines of fault. Some faults, such as No. 4, depart somewhat from this direction, and have an orientation more to the E.N.E.-W.S.W., and there is a correspondingly change in the line of the ridge associated with it.

On the north-west side of these ridges the slopes are generally steep and scarp-like, but on the south-east they are more gentle even where the covering beds have been stripped away. The maturity of the sculpture on these slopes varies considerably; in some cases the dissection of the surfaces has proceeded beyond the infancy stage, suggesting that either the original surface—*i.e.*, the Cretaceous peneplain—was quite uneven when the covering beds were laid down, or that after having been stripped they have been exposed to erosion for a considerable period. In other cases the stripped surfaces are almost as flat as the sides of a well-pitched tent, and suggest a recent uncovering. It should be mentioned also that the stream-directions are in many cases determined primarily by the fault-lines, for their dominant trend is between north-east and east-north-east—that is, parallel to the faults, and also at the same time parallel to the strike of the weaker Cretaceous sedimentaries which have occupied the angle formed by the successive down-dropping of parallel blocks.

The so-called "Railroad" at Rakaia Gorge.

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Plates 65, 66.

ON pages 388–90 of Haast's *Geology of Canterbury and Westland* (with plate), (Christchurch, 1879), there is a description of a peculiar landscape feature near Rakaia Gorge, locally known as the "Railroad." Haast describes this in some detail, and ascribes its formation to glacier-action, an explanation which presents serious difficulties some of which Haast, no doubt, clearly recognized—so that the joint authors of this paper have thought that the problem might very well be restated. The conclusions they have arrived at are the result of observations made separately on various occasions, and jointly during three recent visits to the locality.

The feature referred to may be briefly described as resembling a broad railway-cutting, hence its name (see Plates 65 and 66). It is three miles long, about five chains wide at its upper end, six chains in its middle portion, and between six and seven—perhaps more—at its termination. It runs in a south-easterly direction from the top of the high bank of the Rakaia near the Bayfield Homestead, where the river has excavated its bed to a depth of some 600 ft. in gravels and old lake-silts, to the northern slopes of Bryant's Hill, a rhyolite *roche moutonnée* near the lower end of the gorge. In this distance it climbs four old river-terraces, but ends at a slightly lower level as compared with that at which it starts. The first terrace is only about eight chains wide, but the features of the "Railroad" are not marked at this point. They begin to be distinct on the top of the next terrace, where the depression may really be said to commence (see Plate 66), and from this to the end the ground falls about 40 ft. according to aneroid readings; but it must be remembered that as each successive terrace is encountered there is a marked rise in the bed (Plate 65, fig. 2), and this is also the case near the end as Bryant's Hill is approached, in the vicinity of which the terraces disappear.

The depth of the depression below the level of the adjoining land-surface varies from about 20 ft. at a maximum on the top of the third terrace—it is 15 ft. on the top of the second terrace—to nothing on Bryant's Hill; but it must not be assumed that the decrease is regular, since in one section the difference in level may be pronounced, while in any adjacent section it may be slight or absent. In general, the greatest depth appears to be just on the edge of a terrace, with a progressive diminution in depth as the depression is followed to the bottom of the next terrace, where its boundaries may become quite indistinct. This peculiarity should be noted in connection with the features attributable to wind-action. Also, the depth on opposite sides of the same section is not uniform. In general, it is greater on the side where the neighbouring land is at a slighter higher level than it is on the other side of the "Railroad." Thus there is no marked difference on the top of the second terrace, which is somewhat flat, and which

is met by the line of the depression nearly at right angles; but in the case of the next terrace the circumstances are entirely different (see Plate 65, fig. 2). Here the angle between the line of the depression and that of the edge of the terrace is considerably less than a right angle, and on the north-eastern side the bank is much higher than on the south-western side; whereas on the ridge leading up to Bryant's Hill, where the slope of the ground is to the north-east, the bank is decidely higher on the south-western side. A distinctive feature is the presence of a raised bank on either side, somewhat like a natural or artifical river levee, with a height above the level of neighbouring land-surface ranging usually from 0 to 4 ft., but occasionally as much as 6 ft. Where it could be examined it proved to be formed of wind-blown material similar to the soil covering large areas of the Canterbury Plains. The accumulation of loose material is most marked at the upper end nearest the river, whence plentiful supplies are derived, partly from the present river-bed, and partly from the glacial silts of the old Rakaia lake, which occupied a depression behind the rock bar near the gorge immediately after the retreat of the ice. The fine material is swept from this area by the powerful north-west winds which are a notable meteorological feature of the district (note such names as "Windwhistle Point" and "Windwhistle House"). In none of the loose material did we see any angular blocks, although Haast says that they do occur sparingly. There is no doubt whatsoever that the formation of the levee must be credited almost wholly to wind-action.

The floor of the depression is covered with rounded and subangular blocks with an admixture of soil similar to that composing the bank. The soil is in places somewhat scanty, but occasionally it forms rough irregular mounds. These were considered by Haast to be morainic heaps, but those examined by us were rather ot the nature of dunes, such as occur now in places near the edge of the high terraces. There are similar banks of wind-blown material off the line of the "Railroad" to the west, where there is a considerable area of land from which the soil has been swept and deposited in irregular heaps at the bottom of an adjacent terrace. At this spot, too, as well as near the tops of gullies reaching up from the river-bed, there are long trailing mounds of loose material formed parallel to the direction of the wind, as well as irregular mounds lying across its path. The irregular ridges lying on the first terrace practically opposite the end of the depression may quite well be attributed to this cause, their alignment with the edges of the depression being perhaps a coincidence.

However, in view of the widespread occurrence of morainic blocks in the neighbourhood, it is quite possible that some of the heaps in the floor of the depression may be morainic or may have a core of morainic material. In places, usually along the base of a terrace, the floor of the depression is swampy, the water which accumulates being due either to the formation of pond-like hollows in the dune-complex, or to the presence of a small stream which has followed along the bottom of an old river-terrace, where the ground is, as a rule, somewhat lower.

Perhaps the most remarkable feature of the "Railroad" is the way it climbs the old river-terraces, and specially the third terrace, about three-quarters of a mile below the Bayfield Homestead. The terrace is here about 20 ft. in height, and the line of the "Railroad" turns off at an angle of 15°, ascends the rise obliquely, and then reverts to its former direction (see Plate 65, fig. 2). Whatever the cause of this landscape feature, it is certainly of a date posterior to the formation of this terrace and the others

Fig. 1.—View looking north-west up the Rakaia Valley, taken from the top of the third terrace, showing general features of the "Railroad." Faceted slopes of Mount Hutt on the left.

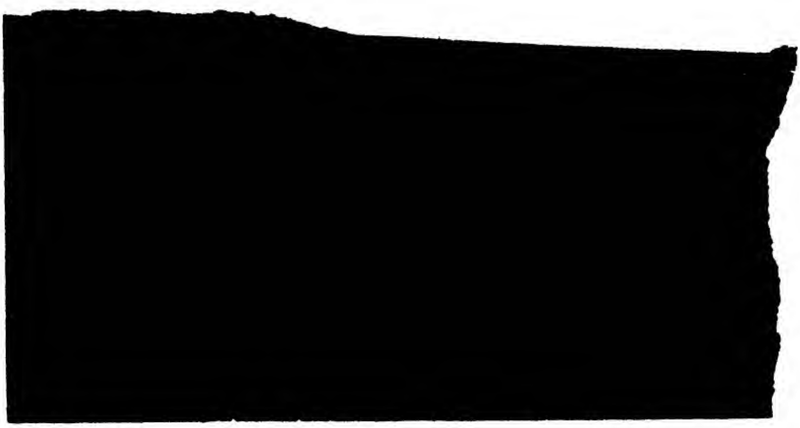

Fig. 2.—View looking south-east from the base of the third terrace, showing "Railroad" rising over the terrace, with higher bank on the left; a of dunes almost in alignment with this bank.

Face p. 628.]

View looking south-east near top of the second terrace, close to the Bayfield Homestead. The banks of the Railroad are near the margins of the picture, the floor of the depression being planted with *Pinus radiata*; the depth of the depression may be inferred by comparison with the height of the wire fence. The slight rise in the foreground on the left is merely an irregular heap on the floor of the main depression, and of no special importance, being quite an accidental feature.

which it crosses. The rise from the river over the first terrace noted by Haast is, in our opinion, somewhat delusive, and is due to the accidental formation of dunes in an approximate line with the edges of the depression. Finally, there is a point which must be noted as to variations in width— viz., the presence of a number of contractions due to reductions arranged in rectangular steps. These are excellently shown where the line of the depression edges away on climbing the terrace just referred to.

The possible explanations of the origin of this landscape feature which should be considered are as follows:-

1. It is an old stream-bed. This is ruled out of consideration on account of the rising grade on meeting old river-terraces (see Plate 65, fig. 2), and also on reaching the slopes of Bryant's Hill.

2. It is the bed of a glacier. If this is so the phenomenon is unique; but there are insuperable objections against this explanation. The side levees are, according to Haast, old lateral moraines, but they are composed almost entirely, even according to his own showing, of fine material, and are not formed of the angular blocks usually constituting moraine. Then, again, it is difficult to imagine the precise method by which a glacier eroded such a hollow, climbed terraces without appreciably disturbing the material of which they are formed, and finally occupied the crest of a ridge leading up to Bryant's Hill. The most decided piece of evidence against a glacier origin is based on the fact that the phenomenon dates from a time posterior to the formation of the whole terrace-system of the locality. These terraces are formed by stream-action in an area from which the ice had disappeared; and they are to be attributed entirely to the work of streams issuing from the ice-front as it retreated up the valley. Had they been pre-glacial they could not have survived in their entirety the erosive action of the great glacier which passed over the ground between Mount Hutt and the Rockwood Range, where the ice must have been from 1,000 ft. to 1,500 ft. deep (note the height of the faceted slopes of Mount Hutt in Plate 65, fig. 1). It is certain however, that there were at least two, probably several, periods of glacier advance and retreat, but these have not yet been definitely determined, and, in any case, the objections made to the glacier explanation will hold good even if the advance was of minor importance. If, then, the terraces are post-glacial, the phenomena must be post-glacial and cannot be credited to ice-action.

3. It is due to wind-action. While admitting that wind is responsible for certain features, one cannot credit wind with forming an excavation with subparallel sides, three miles in length, and cut out of terrace-gravels, and perhaps out of underlying rhyolite. Although this rock is not visible in the floor, yet it certainly lies at a shallow depth, judging from the neighbouring exposures, and it may be covered by a thin veneer of loose material in the track of the excavation.

4. It is due to faulting. According to this explanation it may represent an earthquake-rent, such as can be seen near Glen Wye, on the upper Waiau River (see McKay, *Report of Geological Explorations for 1890–91*, p. 16). If this explanation is correct, the depression can be attributed to trough-faulting. This will explain the long subparallel margins, and the rectangular modifications of width can be regarded as due to fault splinters of the main fault-line. Although we think this explanation the most satisfactory, we have arrived at it largely by the method of exclusion, and not because there is positive evidence of faulting along the line. Evidence of dislocation was looked for where the upper end terminates on a high cliff-like bank facing

the river, but the absence of any distinct bed which could be used as a reference level made investigation unsatisfactory. The only bed which promised anything of value was a layer of large subangular boulders near the top of the bank, which no doubt formed the floor of an older river-channel now buried up by fine wind-blown material. There was, however, no sign of any dislocation in this layer, nor in the bands of finer material interstratified in the coarser gravels; but the conditions attending the deposit of gravel and silt in such positions render them extremely unreliable in matters of this kind, and especially so where the exposures are not clear and where the slumping of incoherent beds from a high river-terrace is reasonably certain to have occurred. A local difference in level of the bed of large boulders just referred to may be attributed to river-scour when the bed was being laid down; it is also slightly off the line of the depression, which makes a turn of about 10° at its upper end, and as a result no clear exposure on its line occurs. The possibility of any supposed dislocation petering out must also be considered. The raised banks nearly on a line with the depression are perhaps due to trails of wind-blown material which has come up a gully leading from the river-bed, and their alignment as they reach the level of the next terrace has been determined by the position of the margins of the depression, an agreement in line or arrangement which is well shown on the wind-scoured terrace to the westward, and which is connected in some way with the wind-eddies there formed.

There is some faulting in the vicinity, for the rhyolite rocks in the gorge are extensively slickensided (in one place they have been pushed over undoubted glacial deposits); but this implies a movement with a N.E.-S.W. orientation. There is strong evidence that the Rakaia Valley is primarily of tectonic origin (see E. Dobson in his report for the year 1865 on "The Possibility of constructing a Road through the Otira Gorge"; and Speight on "The Orientation of the River-valleys of Canterbury," *Trans. N.Z. Inst.*, vol. 48, pp. 142–43, 1915). If this is so, then the axis of the deformation is oriented in a N.W.-S.E. direction, parallel to the general direction of the "Railroad."

It is thus possible that the movements may have continued down to a very late geological time. There are definite occurrences of recent dislocation on this line—*e.g.*, that recorded from the Waipara Valley by Speight and Wild (*Trans. N.Z. Inst.*, vol. 50, pp. 76–77, 1918), as well as of dislocations on other lines—so it is not improbable that the phenomena may indicate such a movement.

It is possible that the levees may have been formed as a result of lateral squeezing, but judging from the loose nature of the material of which they are composed they must be almost entirely attributed to wind-action. The line of the depression lies right in the direction of powerful winds which would sweep through it with considerable violence, bearing the fine material from the up-stream river-bed, and depositing a proportion of it on the margins where the force of the wind was less and friction greater; and the vigorous tussocks growing in the loamy soil would aid materially, when once they were established, in building up the levees by intercepting an increased amount of the wind-blown material swept through them. The greater height of the levees on the edge of a terrace, and it tailing away somewhat down-stream, so to speak, would easily be accounted for, as the action would be more pronounced just on the edge of the terrace, where local eddies would cause a dropping of the material more readily.

*Some New Zealand Amphipoda: No. 5.**

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Tetradeion crassum (Chilton). (Figs. 1 to 20.)

Cyproidia? crassa Chilton, 1883, *Trans. N.Z. Inst.*, vol. 15, p. 80, pl. 3, fig. 1. *Tetradeion* sp. *typ.* Stebbing, 1899, *Ann. Mag. Nat. Hist.*, ser. 7, vol. 4, p. 207. *Tetradeion crassum* Stebbing, 1906, "*Das Tierreich*" *Amphipoda*, p. 157.

The original description of this species, drawn up in 1883, was based on two specimens only, the smaller of which, probably immature, was dissected. Since then numerous other specimens have been obtained from Lyttelton and other localities, and a fuller description is desirable, since the original account, though accurate enough as far as it goes, was defective in that it contained no reference to the mouth-parts and an important character—viz., the reduced condition of the fifth peraeopod—was overlooked.

The species was provisionally placed under the genus *Cyproidia* Haswell, though it was pointed out at the time that it differed very considerably in the character of the side-plates. In this respect the species approaches closely to *Stegocephalus* and allied genera, but descriptions and figures of these were not available in New Zealand at the time. In 1899 Stebbing established the genus *Tetradeion* for the species, and gave the following diagnosis based on the original description:—

"Body short and stout, pleon shorter than peraeon. Head small, rostrum obsolete. Side-plates 1 to 4 together forming a continuous shield, the confronted margins of the contiguous side-plates neatly fitting, fourth much broader than first to third combined, fifth much broader than deep, fitting hind emargination of fourth, sixth and seventh concealed. Eyes well developed. Antennae 1 and 2 small. Antenna 1 the stouter, without accessory flagellum. Antenna 2, penultimate joint of peduncle shorter than antepenultimate. Mouth-parts unknown. Gnathopods 1 and 2 equal, similar, imperfectly subchelate, fourth and fifth joints slightly produced. Peraeopods 1-5 slender, character of second joint unknown, but expansion rendered needless by the great extent of side-plate 4. Uropod 1, rami shorter than peduncle, subequal. Uropod 2 reaching as far back as uropod 1, rami a little unequal. Uropod 3 not reaching so far back as the other pairs, stouter, rami decidedly unequal. Telson entire, oval, short."

To this must be added a note on the mouth-parts, which prove to be very similar to those of *Phippsia gibbosa* (Sars), and to the fact that the

* Previous numbers of this series have appeared in *Trans. N.Z. Inst.* as follows: No. 1, vol. 52, p. 1; No. 2, vol. 53, p. 220; No. 3, vol. 54, p. 240; No. 4, vol. 55, p. 269.

fifth peraeopod is small, entirely concealed by the greatly expanded side-plate of the fourth segment and consists of a small oval plate representing the basis followed by a minute joint which is all that remains of the rest of the limb.

The following amended diagnosis of the genus may therefore be given:—

Tetradeion Stebbing, 1899.

Body short and stout, smooth, head small. Side-plates 1–4 together forming a continuous shield, the contiguous margins neatly fitting, fourth larger than first to third combined, fifth small, fitting into emargination of the fourth, sixth and seventh obsolete. Antennae 1 and 2 small. Mouth-parts similar to those of *Phippsia*. Gnathopoda 1 and 2 similar, not sub-chelate, merus and carpus slightly produced, propod small. Peraeopoda 1 to 4 slender, basal joints not expanded, 5 greatly reduced, consisting of a small plate representing the basal joint. Uropoda short. Telson oval, short, entire.

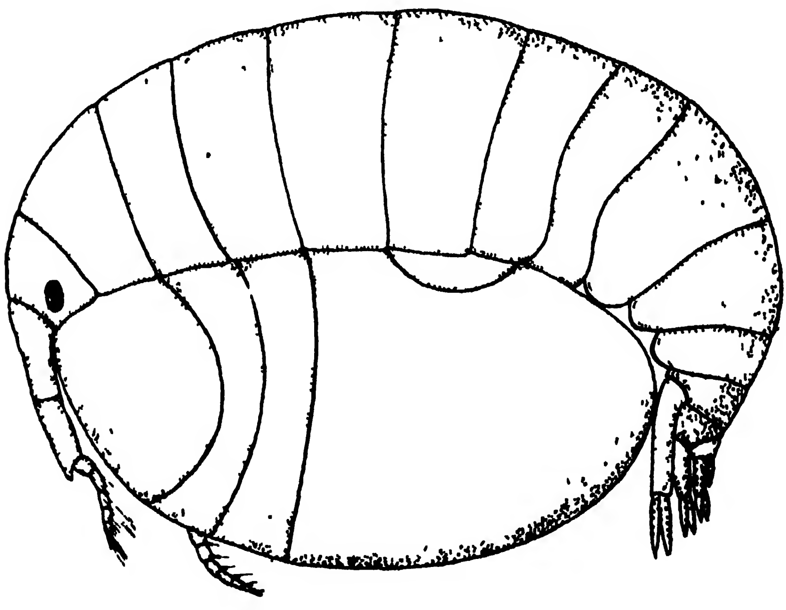


FIG. 1.—*Tetradeion crassum* Chilton: side view of whole animal.

The typical species, and at present the only one known, is *Tetradeion crassum* (Chilton) (see references above), the diagnosis of which is included in that of the genus.

Colour dark slate, sometimes with lighter patches on some parts of the body.

Length of body, in coiled position, about 3 mm.; greatest breadth, 2 mm.; depth, 1·5 mm.

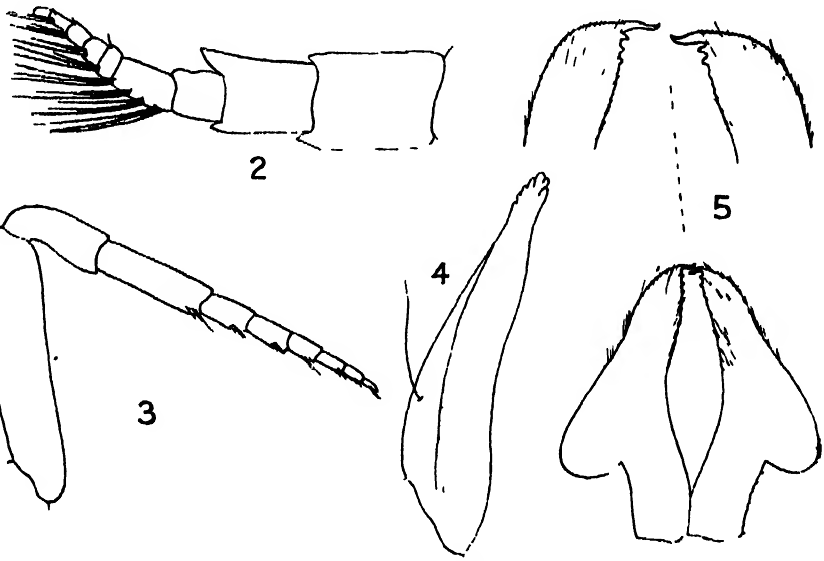
Localities: Lyttelton Harbour, Oamaru, and Hawke's Bay.

Remarks.—From the detailed description given below it will be seen that this species presents many similarities in the general shape of the

body, the mouth-parts, and other appendages to *Phippsia gibbosa*, but in that species the fourth and fifth peraeopoda are not covered by the fourth side-plate, and the fifth peraeopod, though smaller than the fourth, has all the joints perfect.

It is evident that the genus *Tetradeion* must be placed in the family Stegocephalidae, coming close to *Phippsia* Stebbing (= *Aspidopleurus* Sars). It represents a further development along the same line, but has the fourth side-plate still more largely developed and concealing the sixth and seventh, and in consequence peraepod 5 is very greatly reduced.

Detailed Description.—Body smooth, broad, and greatly swollen, side-plates of the first four segments much deeper than their respective segments and strongly convex, so that the appendages of the head and peraeon and the whole of the pleon can be concealed from view when the animal is coiled up the outline of the whole body then being ellipsoid. (Fig. 1.)



Tetradeion crassum Chilton.

FIG. 2.—First antenna.
FIG. 3.—Second antenna.
FIG. 4.—Mandible.

FIG. 5.—Lower lip, with extremity more highly magnified.

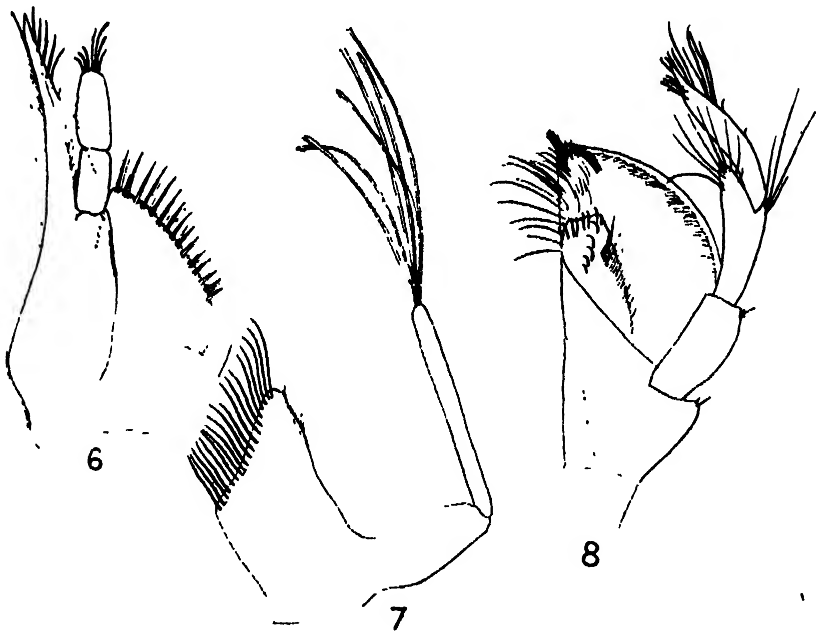
First side-plate subtriangular in outline, its posterior margin very convex; second strongly curved, narrow, only about one-fifth as wide as deep; third similar but less curved; fourth enormously expanded, forming a large convex shield with anterior margin nearly straight and the rounded posterior margin extending as far as the hinder end of third pleon segment; fifth side-plate small, forming a small plate fitting into an emargination on upper margin of fourth; sixth and seventh not developed, the whole of the corresponding appendages being covered by fourth side-plate. Head shorter than first peraeon segment; segments of peraeon subequal in length; first segment of pleon longer than second, third much shorter than second, lower margins of all three convex

and only slightly produced; fourth, fifth, and sixth pleon segments very small. (Fig. 1.)

Eyes of moderate size, rounded, black.

First antenna short and rather broad; first joint of peduncle not much longer than broad, second about three-fourths as long as first and about two-thirds as broad, produced at upper anterior angle into a subacute tooth or lobe, third joint small, about half as long as second; flagellum about two-thirds the length of peduncle, about six-jointed, first joint nearly as long as the next three and probably formed by coalescence of third or fourth joints; all joints of flagellum bearing tufts of long hairs on posterior or inner margins. (Fig. 2.)

Second antenna slender and longer than first, sharply bent backwards at end of first visible joint, which probably represents the third peduncular joint and is longer than the next two together, penultimate joint curved at base, about three-fourths as long as last joint of peduncle; flagellum six-jointed, about as long as last two joints of peduncle. (Fig. 3.)



Tetradeion crassum Chilton.

Fig. 6.—First maxilla; outer lobe seen in profile.

Fig. 7.—Second maxilla.

Fig. 8.—Maxilliped.

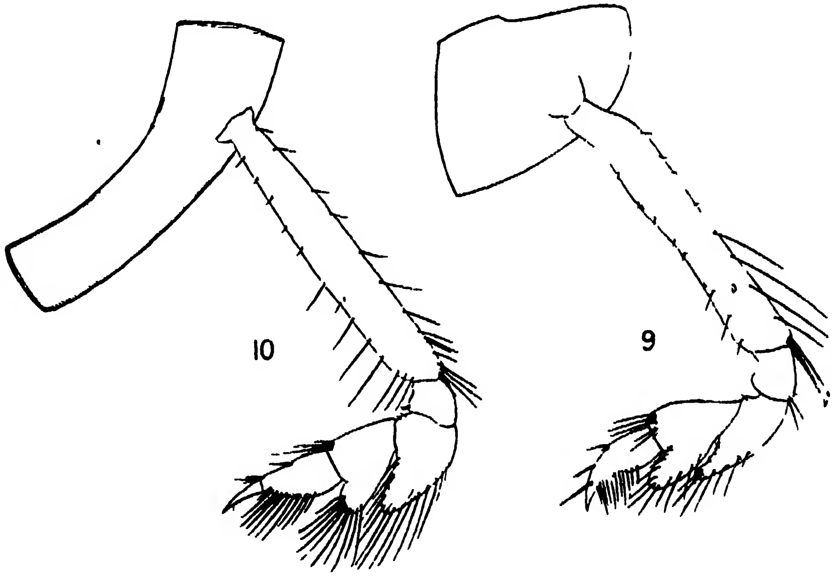
The mouth-parts prove to be very similar to those of *Phippsia gibbosa* and in both genera have probably been modified in correlation with the enormous development of the side-plates and the habits of the animal arising in connection therewith.

Mandible slender, elongated, nearly straight, cutting-edge formed of about six or seven short teeth; inner cutting-edge, spine row, molar tubercle, and palp entirely absent unless a long seta on the outer surface represents the palp. (Fig. 4.)

Lower lip slender, without inner lobes, outer lobes covered with numerous fine hairs, narrowing towards the extremity, which is produced on inner side into three or four teeth, the end one of which is much longer than the others. (Fig. 5.)

In the first maxilla the palp consists of two subequal oblong joints, the terminal one bearing a tuft of six or seven setules; outer lobe not well seen and represented in side view in fig. 6, but apparently ending as usual in several stout setules and bearing fine hairs along margins; inner lobe very large, inner margin convex and fringed with a row of about fifteen to twenty setules with fine hairs between them. (Fig. 6.)

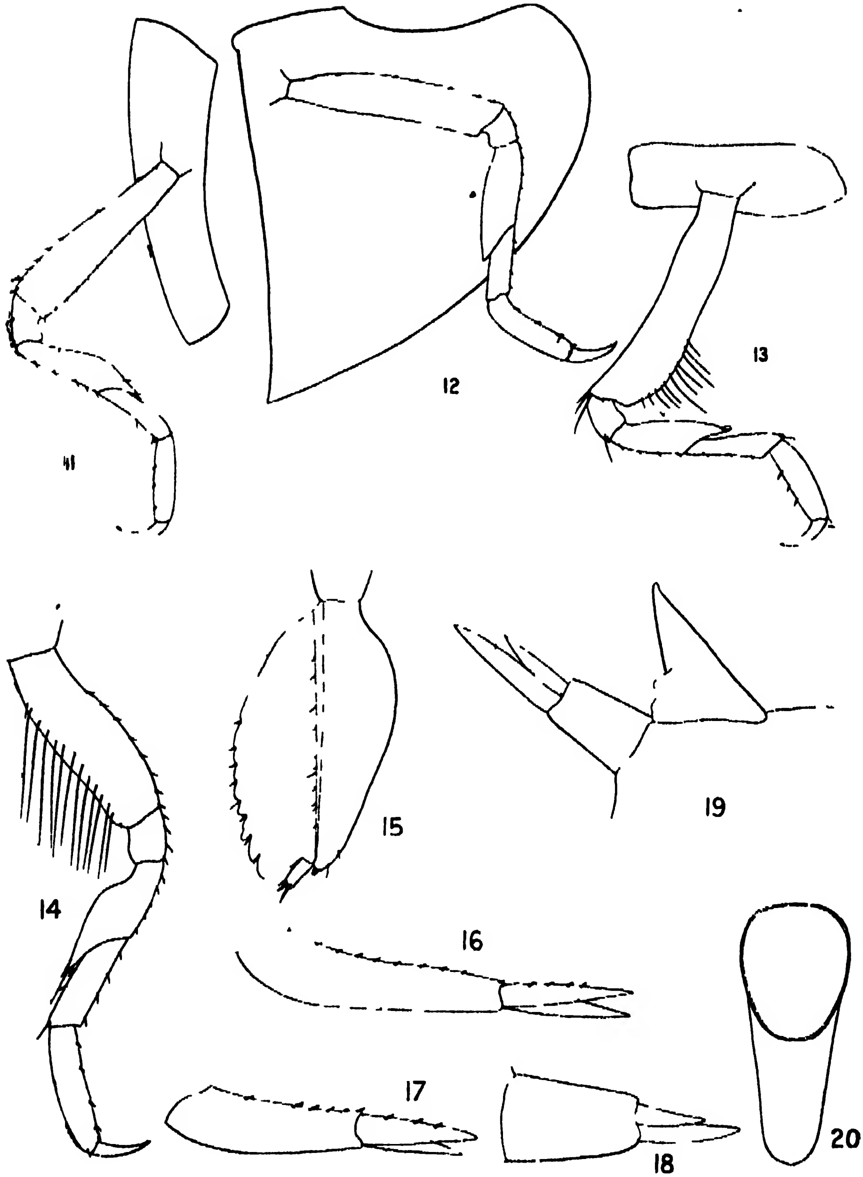
The second maxilla with inner lobe broad, obliquely truncate at extremity, which bears about twenty long setules and a tuft of fine hairs on outer margin near distal end; outer lobe very slender and apparently jointed to a process extending outwards from base of inner lobe; it is free from setae except at the extremity, which bears six very long setules, the ends of which appear to be hooked or barbed. This outer lobe probably forms a brush for sweeping food-particles from the maxillipeds and other mouth-parts towards the mandibles. (Fig. 7.)



Tetradeion crassum Chilton.

FIG. 9.—First gnathopod. | FIG. 10.—Second gnathopod.

Maxillipeds with palp small and lobes very large; inner lobe narrow oblong, end truncate and bearing several stout setules and hooks, distal half of outer margin with thick fringe of long fine hairs; outer lobe very broad, nearly semicircular in shape, its outer margin very convex, apparently turned inwards and fringed with a row of fine hairs, inner margin straight, surface near inner distal angle bearing several stout curved setules; palp formed of three subequal joints, the second produced on inner side into an oval lobe fringed with long setules and bearing a tuft at outer distal angle,



Tetradeion crassum Chilton.

Fig. 11.—First peraeopod.
Fig. 12.—Second peraeopod.
Fig. 13.—Third peraeopod.
Fig. 14.—Fourth peraeopod.
Fig. 15.—Fifth peraeopod.
Fig. 16.—First uropod.
Fig. 17.—Second uropod.
Fig. 18.—Third uropod.
Fig. 19.—Telson and third uropod, seen from the side.
Fig. 20.—Telson detached from the body and seen from below.

terminal joint narrow, curved, its extremity acute and probably representing the minute dactyl almost fused to the end of the propod. (Fig. 8.)

First gnathopod with basal joint very long and narrow, much longer than rest of limb, its margins with a few short setules and some long ones towards postero-distal angle, merus produced into a narrow lobe fringed with setules, carpus about as long as merus and with a similar but broader lobe, terminal joint probably representing fused propod and dactyl, curved towards the acute apex, inner margin with a row of setules, outer margin with three setules or small tufts. (Fig. 9.)

Second gnathopod similar to first but with lobe of merus broader and dactyl distinct from propod. (Fig. 10.)

First peraeopod normal, its basal joint much shorter than rest of limb; merus longer than either carpus or propod, its antero-distal angle produced into a small subacute lobe; carpus and propod subequal, dactyl strong, curved, nearly half as long as propod; setules on different joints few and short. (Fig. 11.)

Second peraeopod similar to first. (Fig. 12.)

Third peraeopod with basal joint elongated, narrow, its posterior margin bearing a row of long hairs towards distal end, remaining joints similar to those of preceding peraeopoda. (Fig. 13.)

Fourth peraeopod similar to third but with basal joint shorter and broader and bearing a row of long hairs extending along nearly the whole of posterior margin. (Fig. 14.)

Fifth peraeopod greatly reduced and forming a suboval plate which probably represents the basal joint; posterior margin of this plate irregularly serrate towards distal end, surface bearing a row of short setules running longitudinally down middle of joint; at end of the plate is a short oblong joint with two or three setules at apex. (Fig. 15.)

First uropod has basal joint greatly elongated, about twice as long as rami, which are equal in length and lanceolate in shape; a row of short setules on upper margin of basal joint and on outer ramus. (Fig. 16.)

Second uropod similar but shorter, basal joint being one and a half times as long as outer ramus which is a little longer than inner. (Fig. 17.)

Third uropod with basal joint stout and longer than outer ramus, inner ramus about two-thirds as long as outer, whole uropod almost or quite free from setules. (Fig. 18.)

The telson as seen in side view is triangular and projects dorsally; when detached and viewed from below the area of attachment appears oval in outline, narrowing posteriorly, and the projecting portion as a plate narrowing somewhat to the broadly rounded extremity. (Figs. 19 and 20.)

The Recorded Calliphoridae of New Zealand (Diptera).

By J. R. Malloch, Washington, D.C.

Communicated by Morris N. Watt, F.E.S.

[*Read before the Wanganui Philosophical Society, 28th October, 1921; received by Editor, 10th October, 1923; issued separately, 28th August, 1924.*]

The following keys include all the genera and species of Calliphoridae that are known to me to occur in New Zealand and adjacent islands. The purpose in publishing the paper is to make available to New Zealand students of Diptera a means by which they may be enabled to identify the species of this group, no keys being available for this purpose except those published many years ago by the late Captain Hutton, which are not up to date in the matter of generic characters.

The family contains species which have a vertical series of strong bristles on middle of the hypopleura below the mesopleural spiracle, the arista plumose to or almost to apex or to middle. The body-colour is generally bluish or greenish, sometimes brassy or bronzy.

The family Sarcophagidae are most nearly related to this group, but the colour of the New Zealand species of the former is invariably greyish, the abdomen being checkered black and grey, and the thorax black vittate. The number of bristles on the area between the presutural dorsocentrals and humeral area in Sarcophagidae is either two or three, exclusive of the notopleural bristles, while in Calliphoridae there are generally five; if less, the species is brilliantly blue-metallic-coloured.

Key to Genera.

1. Eyes distinctly hairy .. .. *Calliphora* Linné (part).
   Eyes bare 2
2. Lower calyptra bare on disc above; a chitinized plate extending forward from anterior lower angle of scutellum between lower calyptra and lower margin of vertical part of hind-margin of mesonotum, which is more or less densely haired; eyes of male much more narrowly separated than those of female .. *Lucilia* Linné.
   Lower calyptra bare above; no hairy chitinized plate as above; eyes of male much more narrowly separated than those of female .. .. .. *Pollenia* Rob.-Desv.
   Lower calyptra more or less distinctly haired at least at base above; no hairy chitinized plate extending from scutellum as described above 3
3. Basal part of radial vein basad of humeral vein with short fine hairs above and behind; thorax and abdomen brillant blue; lower calyptra with hairs on entire surface above .. .. .. *Chrysomyia* Rob.-Desv.
   Basal part of radial vein without such hairs 4
4. Eyes of male as widely separated as those of female, frons about one-third of the head-width; lower calyptra haired on its entire surface above .. *Xenocalliphora* n. gen.
   Eyes of male much more narrowly separated than those of female; lower calyptra long-haired above on basal half, bare on apical half .. .. .. *Calliphora* Linné (part).

Lucilia Linné.

Only one species, *caesar* Linné, has been reported, so far as I know.

Pollenia Robineau-Desvoidy.

Sepimentum Hutton can not be held distinct from *Pollenia*. Structurally and in chaetotaxy the genotypes of the two, which I have carefully examined, cannot be separated except in such details as are only specific and not generic. I would therefore sink *Sepimentum* as a synonym of *Pollenia*, and after examining the type specimens of Hutton's two species I have arrived at the decision that *demissum* must be considered as a synonym of *fumosum*. The species will thus stand as below:

Pollenia fumosum (Hutton).

Sepimentum fumosum Hutton; *Septimentum demissum* Hutton.

The species is evidently common in New Zealand, as I have seen many specimens from Messrs. Watt and Fenwick.

Chrysomyia Robineau-Desvoidy.

I have seen only one species from New Zealand, *rufifacies* Macquart.

The two species which occur in Australia, and which may yet occur in New Zealand, may be separated as below:—

Antennae and face rufous; calyptrae whitish, hind-margin of upper one and posterior half of lower dark brown or fuscous; hairs and bristles of fourth abdominal tergite pale except at base of tergite	*dux* Eschscholz.
Third antennal segment fuscous, face yellowish-red in front below; calyptrae entirely whitish; all setulose hairs of fourth tergite black	*rufifacies* Macquart.

Xenocalliphora n. gen.

Generic Characters.—Differs from *Calliphora* in having the eyes separated by fully one-third of the head-width in both sexes, each orbit with two strong forwardly-directed supra-orbital bristles, and the lower calyptra haired on its entire upper surface,

Genotype: *Calliphora eudypti* Hutton.

There are two species known to me from islands off the coast of New Zealand, and one from New Zealand. They may be separated by means of the key given below:—

1. Thorax with two strong intra-alar bristles on each side; fore tibia with one strong posterior median bristle; legs black; abdomen metallic blue-green, with very slight whitish pruinescence ..	*hortona* Walker.*
Thorax with but one intra-alar bristle on each side; fore tibia with two rather closely placed posterior median bristles	2
2. Apices of femora and entire tibiae and tarsi rufous yellow; abdomen black, with a violet tinge and slight greyish pruinescence on dorsum ..	*eudypti* Hutton.
Legs entirely black, sometimes the extreme apices of femora and the tibiae more or less brownish; abdomen metallic blue-green, with slight greyish pruinescence on dorsum	*antipodei* Hutton.

I have examined only the type series of the last two, but have seen many specimens of the other from New Zealand, sent me by Mr. M. N. Watt.

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* Major Patton has examined the types of Walker's two species *icela* and *hortona* and finds them to be the same species.

Calliphora Linné.

This genus has been subdivided by some authors, but the genera *Neopollenia*, *Paracalliphora*, and *Neocalliphora* are hardly entitled to subgeneric rank, certainly not to generic rank, if one applies the same criteria to the group as to others in the same family. The segregate with hairy eyes, *Neocalliphora* Brauer and Bergenstamm, is the most distinct, but structurally it is very similar to *Calliphora*; and I am not inclined to favour a subdivision on a character which is not even of specific value in some allied groups.

There are two segregates in New Zealand which have apparently escaped separation, and which are probably quite likely to receive attention at some future date. I cannot see that the erection of a new genus to receive the hairy-eyed species would benefit science, nor do I believe that such a course is advisable or permissible, so leave the genus with four species from this region.

KEY TO SPECIES.

1. Eyes hairy	2
Eyes bare	3
2. Palpi and a small raised spot on pleura in front of wing-base orange-yellow; hind-tibia with a rather close fringe of short setulae and bristles on entire length of anterodorsal surface..	*quadrimaculatus* Swederus.
Palpi fuscous, no orange spot on pleura at base of wings; hind-tibia with 4 or 5 short anterodorsal bristles ..	*aureonotata* Macquart.
3. Legs entirely black; venter of thorax and abdomen without conspicuous golden-yellow hairs; abdomen metallic blue, with greyish or whitish pruinescence forming iridescent spots or checkerings; lower calyptra fuscous, with white posterior border; bristles black	*erythrocephala* Linné
Legs fulvous, tarsi fuscous; pleura, venter of thorax and of abdomen with golden-yellow hairs; abdomen olivaceous, with brassy pruinescence forming checkerings; both calyptrae fulvous, bristles of legs in part fulvous	*villosa* Rob.-Desv.

Calliphora quadrimaculatus Swederus.

I have to sink as a synonym of this species *cockaynei* Hutton. I have examined the type specimen of the latter and find that it is identical with specimens which are undoubtedly *quadrimaculatus*, and that Hutton was in error in describing the colour of the abdomen as different from that of the latter.

Calliphora aureonotata Macquart.

I have seen only one specimen of this species, from Wanganui (Watt).

Calliphora erythrocephala Linné.

I have seen this common species, from Wanganui (Watt).

Calliphora villosa Robineau-Desvoidy.

This is the species recorded by Hutton as *laemica* White. It is the genotype of *Neopollenia*, but in my opinion is not separable from *Calliphora*. Common in New Zealand.

N.B.—Hutton's *Calliphora antennatis* does not belong to this family, but to the Anthomyiidae.

Studies on the Crane-flies of New Zealand: Part 1—Order Diptera, Superfamily Tipuloidea.

By CHARLES P. ALEXANDER, Department of Entomology, Massachusetts Agricultural College, Amherst, Massachusetts, U.S.A.

Communicated by J. W. Campbell.

[*Read before the Philosophical Institute of Canterbury, 5th December, 1923; received by Editor, 15th December, 1923; issued separately, 28th August, 1924.*]

INTRODUCTION.

THE crane-flies, or Tipuloidean flies, are well known to all entomological students and collectors in New Zealand, passing often under the vernacular name of "daddies" or "daddy-long-legs." The designation of the southern Maori for these insects would seem to be *te-tatau-o-te-whare-o-Maui*, or, translated, "the door of the house of Maui," a derivation which is not readily explainable (Beattie, *Trans. N.Z. Inst.*, vol. 52, pp. 53–77, 1920). The general appearance of many of the groups and species in the Dominion is very striking as, for example, the magnificent orange-and-black species of *Macromastix*, the green species of the same genus, the abundant species of *Gynoplistia*, the large and showy Cerozodiae with flabellate antennae in the male sex, and the relative abundance of species of *Tanyderus*, a very primitive genus which elsewhere has proven excessively uncommon. Our knowledge of the Tipuloidea of New Zealand received its greatest impetus upon the publication in the last volume of these *Transactions* of Edwards's revision of the species, in which all of the species and data available at the time of writing the paper (1921) are most capably presented.

The great increase in our knowledge of these flies during the past few years has rendered it advisable to publish a series of papers upon this general subject in which the more involved genera can be revised and figured, the detailed lists of species for the various provinces and districts given, the crane-fly fauna of the two Islands critically compared, and similar data presented. In the present article the writer wishes to outline the stages in the historical development of our knowledge of the crane-flies of the Dominion, and to append a bibliography of the papers relating to these flies that have been published to date. Moreover, since a great number of the species that have been described have been based upon a single sex, or even upon a single specimen, it now seems desirable to diagnose the opposite sex of certain of these species and to designate an allotypic specimen. These allotypes are discussed in the concluding portion of this paper.

CHRONOLOGICAL DEVELOPMENT OF OUR KNOWLEDGE OF THE CRANE-FLY FAUNA OF NEW ZEALAND.

Never has the knowledge of the crane-fly fauna of a country been developed more rapidly and efficiently than has that of New Zealand during the past half-dozen years. This is due largely to disinterested collecting of virtually all of the entomological students of the country. At the end of 1918 the entire known Tipuloidean fauna of New Zealand consisted of but fifty-seven species; the total number now known to the writer is more than 350, and additions are constantly being made.

G. V. Hudson, veteran student of the insects of the Dominion, and himself the authority for several species of New Zealand crane-flies (1892, 1895, 1913c, 1920c),* supplied the greater part of the material for the first serious efforts to make this fauna known. A small part of this material, together with additional specimens collected by Helms and Hutton in the South Island, became the property of Osten-Sacken, but were, unfortunately, largely undescribed by this pioneer student of crane-flies, the only species that he made known from this abundant material being *Tanyderus forcipatus* (1880), *Cerozodia plumosa* (1887), and *Discobola dohrni* and *D. venusta* (1894). The next Hudson collection was turned over to Captain F. W. Hutton, and made the subject of the first comprehensive report on these flies (1900). The total number of species recognized by Hutton at this time was forty-four, of which twenty-five are described as new in this paper. Other crane-flies described from New Zealand before the beginning of the twentieth century are few in number. The entomological collections of the voyage of the "Astrolabe" included no Tipulidae and very few Diptera, most of which are wrongly determined in the report. A few scattered species were described by Walker (1848, 1856), based largely on the collections made by Dr. Andrew Sinclair near Auckland in 1845. Schiner (1868) capably discussed the collections made by the entomologists of the expedition of the Austrian frigate "Novara." Nowicki (1875) described his *Macromastix holochlora*, collected by Edwards, and long sunk as a synonym of *M. viridis* (Walker) but now known to be distinct. Butler (1875) added the description of *Dicranomyia fumipennis*, based on a manuscript description by White. Hutton (1881) described *Macromastix vulpina*, while in the same year Westwood characterized *Gynoplistia wakefieldi*. In 1882 Mik published an excellent account of the Diptera collected in the Auckland Islands in 1879 by Krone. Kirby (1884) described several additional species collected by Sinclair.

In 1902 Hutton characterized four additional Tipuloidea, increasing his list to forty-eight. Lamb (1909) described the crane-flies from the sub-antarctic islands collected by Hudson (1909). Alexander (1920) reported upon the Osten-Sacken collection of crane-flies kindly submitted by Dr. Walther Horn and now in the Berlin-Dahlem Museum. At about this same time Hudson sent to the British Museum a large portion of the duplicates of his fine collection of these flies, which were reported upon by Edwards (1923A) in a paper that the present writer would characterize as being the most valuable review of this group of flies that has ever appeared. In this paper Edwards recognizes a total of 159 species, of which ninety-two are described as new. Seven additional species were supplied by Hudson and described by Edwards later the same year (1923B).

Subsequent collecting in the Dominion has demonstrated that Hudson's collections, as studied by Edwards, were exceptionally rich in large and medium-sized species, but that the small and obscure forms were not so well represented. Thus the genus *Molophilus*, of which only five species were known to Edwards, now includes more than fifty species, and bids fair to become one of the largest genera in the Islands. The great increase in our knowledge of these small and medium-sized forms came subsequently to 1920, when Mr. Thomas R. Harris, in the North Island, and Mr. James W. Campbell, in the South Island, and others, became interested in collecting these flies.

* Dates in parentheses refer to the bibliography.

The many lesser subsequent collections have been described in the series of papers by the writer cited in the bibliography (Alexander, 1921–23). M. André Tonnoir's collections (1921–23) have not yet been recorded in print.

DESCRIPTION OF ALLOTYPIC SPECIMENS OF NEW ZEALAND CRANE-FLIES.

A considerable number of the crane-flies described by Hudson, Hutton, Edwards, Alexander, and others were represented by one sex only, sometimes by a single specimen. It is very desirable that the opposite sex be made known, especially in the numerous cases where the descriptions were based upon the female. In the present paper the writer describes the unknown sex of certain of these species, many of which have now been found to be widely distributed in the Dominion. For the type of this opposite sex the writer uses Muttkowski's term "allotype" (*Bull. Pub. Mus. Milwaukee*, vol. 1, p. 10, 1910). Certain Americam entomologists, especially those connected with the National Museum, have recently maintained that a specimen to be an allotype must be selected from the original series of specimens, either co-types or paratypes. Muttkowski's original description states, "If the protolog describes only a holotype male, the first female subsequently described is to be called the allotype." The following year Muttkowski (*Ann. Ent. Soc. Amer.*, vol. 4, p. 207, 1911) restated his opinion of an allotype, and made it clear that this type may be based upon material collected at any subsequent date to that of the type. Since this definition exactly fits the conditions met in the present paper, the writer can see no need for the term "neallotype," proposed as a substitute term by the above-mentioned entomologists.

In the following descriptions the Tillyard modification (*Proc. Linn. Soc. N.S.W.*, vol. 44, pp. 533–718, 1919) of the Comstock-Needham system of wing-venation is used. The terminology of the parts of the male hypopygium is that of Crampton (*Trans. Ent. Soc. Amer.*, vol. 48, pp. 207–25, 1923). The figures of hypopygia are made from specimens cleared and mounted on slides. Allotypes described in the present paper are preserved in the writer's collection.

Tribe LIMNOBIINI.

Dicranomyia fasciata Hutton.

1900. *Dicranomyia fasciata* Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 34.
1923. *Dicranomyia fasciata* Hutton: Edwards, *ibid.*, vol. 54, p. 277.

Hutton's type, a female, was from Christchurch: Edwards had no additional material. The species is widely distributed in the South Island (Canterbury, Westland, Otago, Southland), rarer in the North Island (Ohakune, Wellington).

Allotype.—♂. Length, 6 mm.; wing, 9 mm.

Rostrum and palpi dark brown. Antennae black throughout; flagellar segments oval, terminal segment more elongate. Head brown, grey-pruinose, especially anteriorly. Mesonotal praescutum grey with three brown stripes more or less confluent, anterior ends of lateral stripes bent laterad to margin of sclerite, restricting ground-colour to humeral triangles and a small lateral spot before suture; scutellum dark, caudal margin greenish-testaceous. Pluera brown, grey-pruinose. Halteres brown, base of stem broadly greenish-testaceous. Legs dark brown, the coxae sparsely pruinose, trochanters more greenish, tibiae and tarsi passing into black.

Wings greyish subhyaline with extensive pale-brown markings, the more conspicuous being at origin of Rs, completely traversing cell R; at stigma; along cord and outer end of cell 1st M_2; slightly paler clouds at ends of longitudinal veins, most extensive in anal cells. Venation: Sc_1 ending a short distance beyond origin of Rs, this distance slightly variable, Sc_2 just before this origin; *m-cu* shortly before the fork of M. Abdomen dark brown, posterior margins of outer sternites indistinctly pale; hypopygium dark. Male hypopygium (fig. 1) with basistyles cylindrical, each with squat hemispherical lobe on mesal face at base, this lobe terminating in small tubercle set with a pencil of setae; mesal face of basistyle provided with numerous very long powerful setae. Ventral dististyle simple, a fleshy lobe unprovided with a rostrum; dorsal dististyle a very strongly curved chitinized hook. Gonapophyses with mesal apical angle a slightly curved, feebly bifid, chitinized rod.

Allotype, ♂, Glenorchy, Otago, altitude 1,200 ft.; 4th January, 1923 (*C. C. Fenwick*).

Dicranomyia aegrotans Edwards.

1923. *Dicranomyia aegrotans* Edwards, *Trans. N.Z. Inst.*, vol. 54, pp. 280–81, pl. 27, fig. 22 (wing).

Edwards's type was based on the female specimen mentioned, but not described, by Walker (*List Dipt. Brit. Mus.*, vol. 1, p. 45, 1848). The type-locality is unknown. Widely distributed in both Islands.

Allotype.—♂. Length, 6·5 mm.; wing, 8·3 mm.

Similar to female, differing as follows: Basal flagellar segments pyriform, outermost passing into oval. Mesonotal praescutum with very broad and distinct medium brown stripe, lateral stripes paler and ill-defined, confluent internally with median stripe; scutal lobes with dark centres. Pleura heavily light grey. Legs with femora rather uniformly dark brown, tibiae and basitarsi a little paler. Wings as described for female; base of cell 2nd A strongly infuscated, coloration following distad along vein Cu. Venation: Sc_1 ending just beyond origin of Rs, Sc_2 some distance from its tip and very short, Sc_1 alone about equal to *m-cu*; Rs nearly three times basal deflection of R_{4+5}; cell 1st M_2 normally open by atrophy of *m*. Abdomen dark brown, including the hypopygium. Male hypopygium (fig. 2) characteristic of the species. Basistyles with the mesal apical angle produced caudad into slender finger-like lobe that terminates in two large setae and one or two smaller ones; mesal face of basistyle very densely setiferous. Dististyle single, simple, base enlarged, mesal face at apex produced into conspicuous, chitinized, slightly curved rostrum bearing two long spines just before mid-length, these spines directed strongly basad. Gonapopyses pale, mesal apical angle produced caudad into short black curved spine.

Allotype, ♂, Ohakune, Wellington, altitude 2,060 ft.; 15th October, 1921 (*T. R. Harris*).

Dicranomyia repanda Edwards.

1923. *Dicranomyia repanda* Edwards, *Trans. N.Z. Inst.*, vol. 54, p. 278, pl. 27, fig. 17 (wing).

Edwards's types consisted of three males—two taken by Hudson near Wellington, the third by Dr. Andrew Sinclair and mentioned but not

described by Walker (*List Dipt. Brit. Mus.*, vol. 1, p. 57, 1848). This very distinct and handsome crane-fly is widely distributed in both Islands.

Allotype. ♀. Length, 10·5 mm.; wing, 13·4 mm.

Differs from male only in the following respects: Basal segment of scape concolorous with remainder of antenna. Mesonotal praescutum almost covered by four nearly confluent black stripes, interspaces faintly pruinose; lateral margins of praescutum reddish-brown. Pleura heavily covered with microscopic light-grey pubescence that appears like a bloom. Halteres ochreous, knobs dark brown. Legs with the brown femoral ring subequal in extent to the orange apex beyond it. Abdominal tergites dark brown, paler sublaterally near base of segments. Ovipositor with genital segment obscure orange; tergal valves relatively small but straight, sternal valves ending near mid-length of tergal valves.

Allotype, ♀, Ohakune, Wellington, altitude 2,060 ft.; 1st October, 1921 (*T. R. Harris*).

Dicranomyia nigrescens Hutton.

1900. *Dicranomyia nigrescens* Hutton, *Trans. N.Z. Inst.*, vol. 32, p. 34
1923. *Dicranomyia nigrescens* Hutton: Edwards, *ibid.*, vol. 54, pp. 281–82.

Hutton's type, a female, was from Wellington. Common in parts of Canterbury and Otago.

Allotype.—♂. Length, about 7 mm.; wing, 8·5 mm.

Agreeing closely with Hutton's brief description, differing chiefly in sexual characters.

Median area of scutum a little paler than remainder of mesonotum. Femoral bases narrowly and indistinctly paler. Stigma scarcely darker than remainder of wing. Sc_1 ending opposite origin of Rs, Sc_1 alone shorter than *m-cu*; Rs arcuated at origin, about twice the basal deflection of R_{4+5}; cell 1st M_2 short-rectangular, shorter than any of veins issuing from it; *m-cu* at or close to fork of M. Abdomen brownish-black, including hypopygium. Male hypopygium (fig. 3) with ninth tergite distinctly bilobed, median area near caudal margin with abundant setae. Basistyles small, mesal face of each produced into conspicuous stout lobe. Ventral dististyle large and fleshy, mesal face produced into short rostrum armed with two subequal erect spines, situated not far from base. Dorsal dististyle a gently curved spine that narrows gradually into an acute point. Gonapophyses with mesal apical angle produced caudad into a gently curved lobe.

Allotype, ♂, Glenorchy, Otago, altitude 1,200 ft.; 4th January, 1923 (*C. C. Fenwick*).

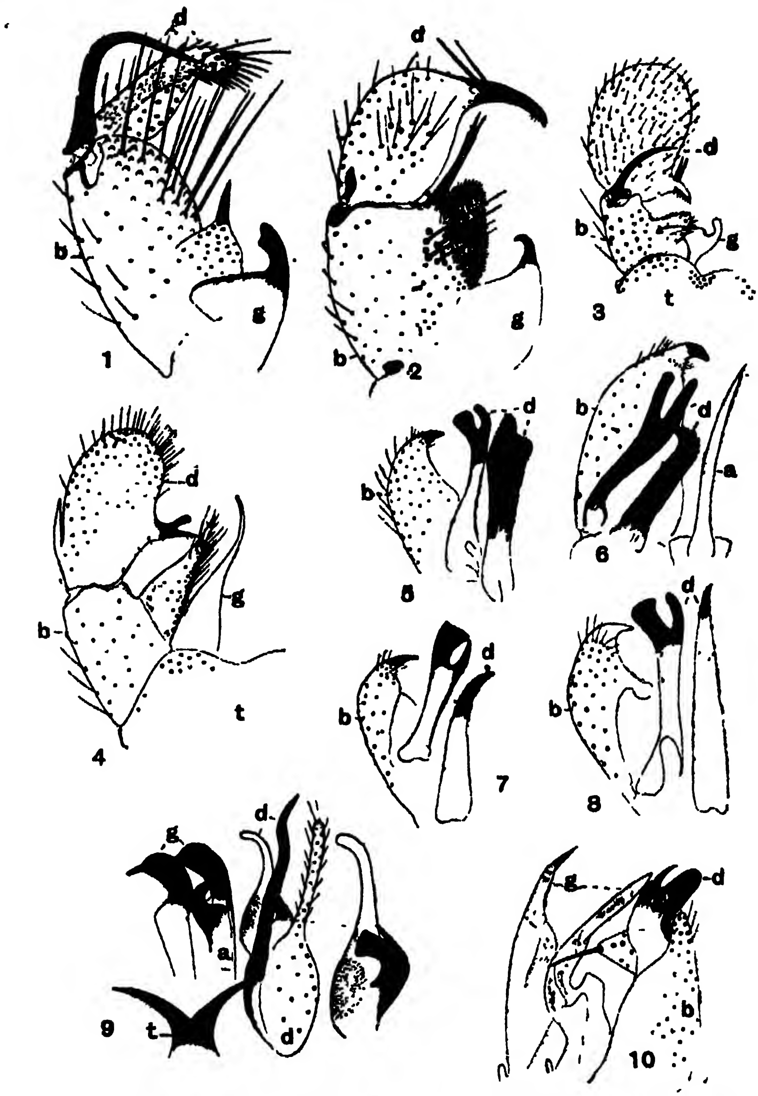
Discobola gibbera Edwards.

1923. *Discobola gibbera* Edwards, *Trans. N.Z. Inst.*, vol. 54, p. 286, pl. 28, fig. 29 (wing).

Edwards's type, a female, was from Tisbury, Southland, collected in 1915 by Philpott. The fly has since been taken in the Provinces of Wellington, Westland, Canterbury, and Southland.

Allotype.—♂. Length, 8·5 mm.; wing, 9·5 mm.

Generally similar to female, differing as follows: Median area of praescutum broadly dark brown, widening behind and suffusing posterior sclerites of mesonotum. Mesopleura almost entirely shiny black. Abdominal tergites brownish-black, caudal margin distinctly, median area more



MALE HYPOPYGIA OF SPECIES OF NEW ZEALAND CRANE-FLIES.

Fig.
1. *Dicranomyia fasciata* Hutton.
2. *D. aegrotans* Edwards.
3. *D. nigrescens* Hutton.
4. *Discobola gibbera* Edwards.
5. *Molophilus cruciferus* Alexander.
6. *M. pulcherrimus* Edwards.
7. *M. parvulus* Alexander.
8. *M. philpotti* Alexander.
9. *Amphineurus horni* Edwards.
10. *Gonomyia nigrohalterata* Edwards.

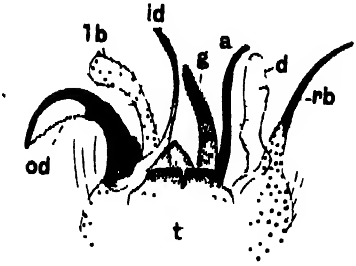
Fig.
11. *Amphineurus subfatuus* Alexander.
12. *A. fatuus* (Hutton).
13. *Aphrophila neozelandica* (Edwards).
14. *Polyymoria nigrocincta* (Edwards).
15. *Limnophilella serotina* (Alexander).
16. *Gynoplistia pedestris* Edwards.
17. *G. arthuriana* Edwards.
18. *Atarba viridicolor* Alexander.
19. *A. filicornis* Alexander.
20. *Elephantomyia zealandica* Edwards.

EXPLANATION OF SYMBOLS.

a, aedeagus.
b, basistyle.
d, dististyle.
i, interbasal process.

i.d., inner dististyle.
g, gonapophyse.
l.b., left basistyle.
l.d., left dististyle.

o.d., outer dististyle.
r.b., right basistyle.
r.d., right dististyle.
t, 9th tergite.



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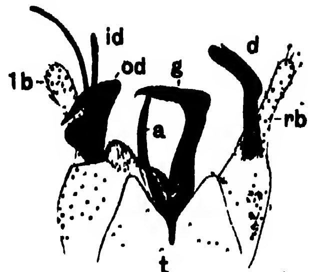

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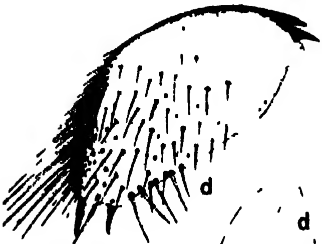

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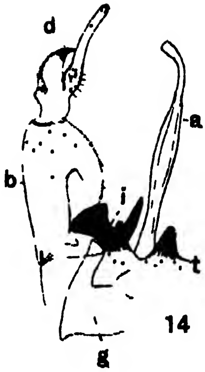

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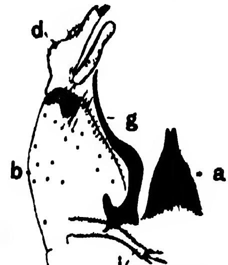

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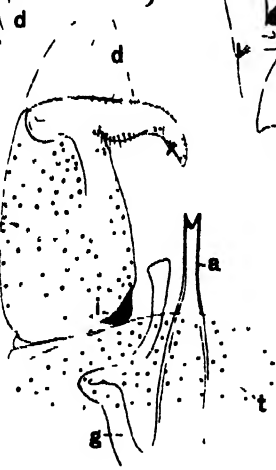

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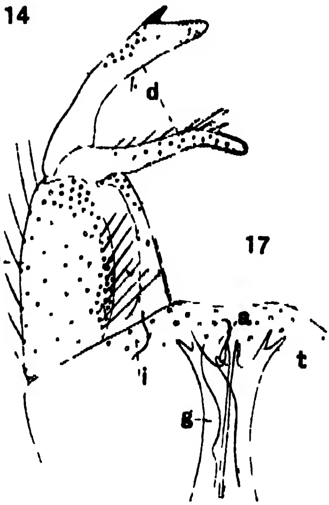

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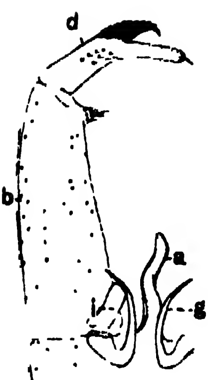

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diffusely obscure yellow; sternites similar, but dark areas more confined to sides of sclerites. Male hypopygium (fig. 4) with ninth tergite feebly emarginate caudally, median area without setae. Basistyles about as long as ventral dististyle, mesal face produced caudad into cylindrical lobe that narrows gradually to apex, which is slender and attenuated. Ventral dististyle moderately fleshy, rostrum bearing two chitinized projections, apical one more spine-like but bearing two tiny setae, the other projection subapical, feebly expanded at apex; what may represent dorsal dististyle is a small, almost straight rod at base of outer face of ventral style. Gonapophyses slender, apical angle produced into a long, feebly sinuous point, the two apophyses together appearing lyriform.

Allotype, ♂, Governor's Bay, Christchurch, Canterbury; 27th November, 1922 (*J. F. Tapley*).

Tribe ERIOPTERINI.

Molophilus multicinctus Edwards.

1923. *Molophilus multicinctus* Edwards, *Trans. N.Z. Inst.*, vol. 54, p. 295.

Edwards's types, males without exact data, collected by Wakefield in 1880. The fly is one of the commonest and most widely distributed species of the genus in the Islands, having been taken in Wellington, Westland, Canterbury, and Otago.

Allotype.—♀. Length, about 4 mm.; wing, 4 mm.

Differs from male only in sexual characters. Antennae brownish-black with shorter flagellar verticils. Mesonotum dark brown, sides of pronotum pale yellow. Femoral annuli yellowish-white, other rings pure-white; basitarsal ring occupying little more than half length of segment. Ovipositor with tergal valves elongate, acicular, rather strongly upcurved, tips acute; sternal valves straight.

Allotype, ♀, Coal Creek Track, Greymouth, Westland; 13th February, 1923 (*T. R. Harris*).

Molophilus cruciferus Alexander.

1922. *Molophilus cruciferus* Alexander, *Ann. Mag. Nat. Hist.* (9), vol. 9, p. 147.

The type, a female, taken by Miller in Thermal Springs region, Auckland. The fly is now known to occur in parts of Auckland and Wellington. This species, as well as the three following, belong to a large and difficult aggregation of New Zealand crane-flies that I have called the *plagiatus* group. The members are separated chiefly upon combinations of size and coloration, venation, and the details of structure of the male hypopygium, especially the shape of the basal dististyle, although the outer dististyle, apical spine of the basistyle, and the aedeagus furnish additional details.

Allotype.—♂. Length, about 3·6 mm.; wing, 4 mm.

Differs from female chiefly in sexual characters. Pleural region damaged in the unique type, very conspicuous, dorsal pleurites covered by broad brownish-black longitudinal stripe, ventral pleurites and mesosternum yellowish, silvery pruinose. Male hypopygium (fig. 5) as in *plagiatus* group; apical beak of basistyle a moderately elongate chininized spine. Outer

dististyle relatively slender, apex bifid, lateral arm dilated into a blade, mesal arm a gently curved obtusely rounded lobe. Basal dististyle conspicuous, appearing as a broad flattened blade, apex feebly expanded into spear-shaped structure, lateral margin of head thus formed with a series of about a dozen acute and slightly recurved teeth; this appendage is darkened, though not blackened, except on basal third which is pale. Aedeagus relatively short and stout, apex suddenly narrowed.

Allotype, ♂, Ohakune, Wellington, altitude 2,060 ft.; 10th October, 1921 (*T. R. Harris*).

Molophilus pulcherrimus Edwards.

1923. *Molophilus pulcherrimus* Edwards, *Trans. N.Z. Inst.*, vol. 54, p. 295, pl. 28, fig. 45 (wing).

Edwards's type, a female, taken at Wellington in December by Hudson. This beautiful little crane-fly is now known to be widely distributed in both Islands (Auckland, Wellington, Nelson, Westland, Canterbury, Otago).

Allotype. ♂. Length, 3·2 mm.; wing, 4 mm.

Generally similar to description of female, differing as follows: Scutal lobes with dark centres; scutellum shiny brownish-black. Fore femora dark, except at extreme base, densely covered with appressed black setae so fore femora appear black in contrast with other legs. Abdomen dark brown, hypopygium brownish-ochreous. Male hypopygium (fig. 6) with basistyles relatively stout, each terminating in chitinized beak that bears a small shoulder before apex. Outer dististyle chitinized, deeply bifid, outer branch weakly toothed at apex. Basal dististyle a stout, almost straight, chitinized rod that terminates in a powerful spine directed laterad, mesal face before this spine with abundant appressed spinulae; a small spine on lateral face of style near two-thirds length. Aedeagus long and slender, almost straight, gradually narrowed to acute apex.

Allotype, ♂, Mount Ruapehu, Wellington, altitude 4,500 ft.; 27th February, 1922 (*T. R. Harris*).

Molophilus parvulus Alexander.

1922. *Molophilus parvulus* Alexander, *Ann. Mag. Nat. Hist.* (9), vol. 9, p. 146.

The types, females, were from Ohakune, taken in November, 1920, by Harris. I have not seen this species except from this locality.

Allotype.—♂. Length, about 2·8 mm.; wing, 3·4 mm.

Base of R_{2+3} very faint to atrophied. Male hypopygium (fig. 7) with apex of basistyle produced into long slender chitinized spine, surrounding base of which are numerous small setae which pass into larger setae on face of style. Outer dististyle relatively short and stout, bifid at apex, lateral arm a conspicuous flattened blade, apex dilated and truncate, extreme outer angle weakly toothed; mesal or inner arm an acute curved spine, apex acute; basal half of this style pale. Basal dististyle pale, only apical third blackened, tapering gradually to acute gently curved tip, before apex with sparse appressed denticles.

Allotopotype, ♂, Ohakune, altitude 2,060 ft.; 1st December, 1922 (*T. R. Harris*).

Molophilus philpotti Alexander.

1922. *Molophilus philpotti* Alexander, *Ann. Mag. Nat. Hist.* (9), vol. 9, pp. 145–46.

The types, females, were taken in the Province of Nelson by Philpott. The species occurs in both Islands.

Allotype.—♂. Length, about 3·7 mm.; wing, 4·4 mm.

Very similar to female, differing chiefly in sexual characters. Antennae short, flagellum dark brown. Abdomen more uniformly brownish-yellow than in type. Male hypopygium (fig. 8) with apical spine of basistyle relatively short and only feebly chitinized, not blackened. Outer dististyle very much as in *M. cruciferus*, the stem stouter. Basal dististyle pale, only extreme tip darkened, apex suddenly narrowed and provided with sparse appressed denticles that pass into small setae basally. Aedeagus long and slender, straight.

Allotype, ♂, Mount Ruapehu, Wellington, altitude 3,700 ft.; 6th January, 1922 (*M. N. Watt*).

Amphineurus (Nothormosia) horni Edwards.

1923. *Amphineurus horni* Edwards, *Trans. N.Z. Inst.*, vol. 54, p. 294, pl. 28, fig. 44 (wing).

Edwards's type, a female, was from Wellington, collected by Hudson. The fly is very common, occurring in both Islands (Wellington, Canterbury, Otago).

Allotype.—♂. Length, about 2·8 mm.; wing, 5 mm.

Differs from female chiefly in sexual characters. Head dark grey. Antennae elongate, longer than body, dark brown, scapal segments a little paler; flagellar segments fusiform, near mid-length of each with numerous elongate erect verticils. Mesonotum greyish-brown, sides of praescutum somewhat darker; pseudosutural foveae elongate, shiny black. Halteres dark brown, base of stem conspicuously ochreous. Legs with coxae and trochanters testaceous; femora brown. Abdomen dark brown, genital segment brighter brown. Male hypopygium (fig. 9) with ninth tergite heavily chitinized, appearing as two divergent chitinized horns. Basistyles relatively stout, outer apical angle produced caudad into slender digitiform setiferous lobe nearly as long as longest dististyle. What appears to be a basal dististyle, but may be an interbasal process, is a long, sinuous, heavily-chitinized rod, directed caudad, apex acute. Outer dististyle complex, longest element a pale elongate blade arising from an enlarged base whose surface appears squamose, at its base with a small curved chitinized appendage, apex expanded into truncate hatchet-shaped blade, outer margin with acute spine (thumb). Aedeagus pale basally, strongly bent before apex, subtended on either side by flattened blade-like gonapophyses which terminate in a slender black spine; viewed dorsally or ventrally, apical third of each gonapophyse more blackened than base and bent strongly mesad so tips are nearly contiguous on median line.

Allotype, ♂, Ohakune, Wellington, altitude 2,060 ft.; 3rd November, 1921 (*T. R. Harris*).

Amphineurus (Nesormosia) subfatuus Alexander.

1922. *Amphineurus subfatuus* Alexander, *Ann. Mag. Nat. Hist.* (9), vol. 10, pp. 87–88.

The type, a female, was taken at Ohakune, Wellington Province, by Harris. The fly is known only from this province.

Allotype.—♂. Length, about 5 mm.; wing, 7 mm.

Agrees closely with type female, differing only in sexual characters. Male hypopygium (fig. 11) with ninth tergite (*t*) squarely truncate, deeply split medially by a narrow incision, surface and margins of lobes finely spiculose, lateral shoulders more spinous. Basistyles with asymmetrical dististyles, as in subgenus. Right basistyle (*r.b.*) produced apically into long curved black spine arising from an enlarged setiferous base; the single dististyle of this side (*r.d.*) an irregular darkened blade, the surface with small scattered setiferous punctures and bearing a small glabrous wing-like projection. Left basistyle (*l.b.*) is produced apically into a very strongly clavate fleshy lobe not unlike that found in *A. fatuus*, but is extended into a weak spine. Dististyles of left side two in number, the outermost (*o.d.*) a chitinized rod, apical half slender, strongly curved and bearing a hyaline setiferous membrane in its concavity; second or inner style (*i.d.*) an acicular rod, sparsely hairy especially on mesal face near base, apex very feebly dilated. Gonapophyse (*g*) a pale-yellow blade that gradually narrows to apex, surface densely setiferous. Aedeagus (*a*) nearly as in *A. fatuus*, narrowed immediately before apex.

In *A.* (*N.*) *fatuus* (Hutton) (fig. 12) the asymmetry is less marked, apical lobes of basistyles (*b*) being nearly alike on the two sides; dististyle of right side (*r.d.*) is bifid, the two arms closely appressed, the obtuse arm with tiny setiferous punctures. The two dististyles of left side very dissimilar in shape, the outermost (*o.d.*) heavily chitinized, narrowed into a beak that is bent strongly upon itself and acutely pointed; face of this style with a series of comb-like teeth or pegs; second or inner style (*i.d.*) an acicular rod profoundly bifid, the two arms unequal. What Edwards describes as the aedeagus seems rather to be a gonapophyse (*g*), the other being much reduced. The true aedeagus (*a*) is very similar to that found in *subfatuus*. Ninth tergite (*t*) has lateral lobes long, obliquely truncate, margins and apices of lobes smooth.

Allotopotype, ♂, Ohakune, Wellington, altitude 2,060 ft.; 22nd November, 1922 (*T. R. Harris*).

The degree of asymmetry in male hypopygium of the two species of *Nesormosia* is very surprising, being somewhat more marked in *subfatuus* than in *fatuus* because of the conspicuous difference in apical lobes of basistyles. From specimens of *subfatuus* received from Mr. Hudson and collected at the time and place of capture of the type of *A.* (*N.*) *niveinervis* Edwards, I am strongly of the opinion that the latter name must be placed in the synonymy of *subfatuus*.

Gonomyia (Lipophleps) nigrohalterata Edwards.

1923. *Gonomyia* (*Lipophleps*) *nigrohalterata* Edwards, *Trans. N.Z. Inst.*, vol. 54, p. 290, pl. 28, fig. 38 (wing).

Edwards's type, a female, was taken at Auckland in September, 1906, by Wesché. The fly is not uncommon in the central and northern portions of the North Island.

Allotype.—♂. Length, about 4·5 mm.; wing, 5·5 mm.

Agrees closely with female. Rostrum scarcely brightened. Scutellum bright yellow; postnotum darkened on posterior half. Pleural stripe narrow but conspicuous, extending from cervical sclerites to postnotum. Abdominal tergites dark brown, sternites and hypopygium obscure yellow. Male hypopygium (fig. 10) with basistyles relatively small, apex of each produced caudad in blunt, setiferous lobe. Dististyles two—one a blunt, fleshy, setiferous lobe that terminates in a powerful fasciculate seta, the other more chitinized, with a short acute black spine near mid-length, this spine shorter than the apex of style beyond it. Gonapophyses slightly asymmetrical, long and slender. Dististyles of one side broken, and it cannot be stated whether or not the hypopygium is asymmetrical as in the related *G.* (*L.*) *longispina* Alexander.

Allotype, ♂, Taumarunui, Auckland; 24th December, 1922 (*T. R. Harris*).

Astelobia rufa (Hudson).

1895. *Tipula rufa* Hudson, *Trans. N.Z. Inst.*, vol. 27, p. 294.
1900. *Gnophomyia rufa* Hutton, *ibid.*, vol. 32, p. 39 40, pl. 4, fig. 13 (wing).
1920. *Gnophomyia rufa* Hutton: Hudson, *ibid.*, vol. 52. pp. 32–33, pl. (col.) 1, figs. 7–9 (larva, pupa, adult).
1923. *Gnophomyia* (*Astelobia*) *rufa* Edwards, *ibid.*, vol. 54, p. 298, pl. 28, fig. 48 (wing).

Hudson's types, males, were taken in dry forest near Wellington. Although Edwards discussed the female sex, he did not designate a specimen as allotype.

Allotype.—♀. Length, 28 mm.; wing, 19·3 mm.

Characters as in male, differing only in sexual characters. Tergal valves of ovipositor long and slender, acutely pointed, strongly upcurved beyond mid-length.

Allotype, ♀, Wilton's Bush, Wellington; 15th November, 1908 (*G. V. Hudson*).

Described from a perfect specimen in my collection, received through the kindness of Mr. Hudson.

Aphrophila neozelandica (Edwards).

1923. *Gnophomyia* (*Aphrophila*) *neozelandica* Edwards, *Trans. N.Z. Inst.*, vol. 54, p. 298, pl. 28, fig. 47 (wing).

Edwards's type is a female, taken at Otira Gorge by Hudson. The species is widely distributed in both Islands, being known from Wellington, Nelson, Westland, Canterbury, and Otago.

Allotype.—♂. Length, 6·5 mm.; wing, 11·5 mm.

Agrees closely with female. Flagellar segments cylindrical. Femora paler basally. Abdomen purplish-black, extreme caudal margins of segments indistinctly paler, this better marked on subterminal segments. Male hypopygium with basistyles relatively stout. Single dististyle (fig. 13) is a broad, flattened blade, apex terminating in two acute teeth and a more obtuse lobe; caudal or outer margin on basal third is densely provided with coarse black setae directed strongly basad; surface of blade likewise provided with setae and microscopic setulae. Base of aedeagus densely set with conical spinulae.

Allotype, ♂, Glenorchy, Otago, altitude 1,200 ft.; 4th January, 1923 (*C. C. Fenwick*).

Tribe HEXATOMINI.

Nothophila fuscana (Edwards).

1923. *Ulomorpha fuscana* Edwards, *Trans. N.Z. Inst.*, vol. 54, p. 305, pl. 29, fig. 54 (wing).

Edwards's type, a male, was taken near Wellington in April. The species occurs in both Islands, flying late in the season.

Allotype.—♀. Length, 11 mm.; wing, 11·3 mm.

Very close to male, differing chiefly in sexual characters. Head greyish-brown. Praescutal stripes confluent. All tergites margined caudally with buff. Wings fully developed, as in male. Ovipositor with long, slender, gently upcurved tergal valves.

Allotype, ♀, Wellington; April, 1922 (*G. V. Hudson*).

Nothophila nebulosa (Edwards).

1923. *Ulomorpha nebulosa* Edwards, *Trans. N.Z. Inst.*, vol. 54, pp. 304–5, pl. 29, fig. 53 (wing); pl, 33, fig. 143 (hypopygium).

Edwards's types, males, were from near Wellington, taken in April by Hudson. Like the preceding species, the fly is a characteristic late-summer or fall species, but so far has not been taken except in the near vicinity of the City of Wellington.

Allotype.—♀. Length, about 12 mm.; wing, 12·7 mm.

Generally similar to the male, differing as follows: Wings fully developed, as in male. Ovipositor with tergal valves as in preceding species; sternal valves stouter than tergal valves, short and nearly straight.

Allotype, ♀, Wilton's Bush, Wellington; 20th April, 1922 (*G. V. Hudson*).

Polymoria nigrocincta (Edwards).

1923. *Limnophila nigrocincta* Edwards, *Trans. N.Z. Inst.*, vol. 54, pp. 312–313, pl. 29, fig. 59 (wing).

Edwards's type, a female, was taken at Wainuiomata, Wellington, in December, 1920, by Hudson. The fly is widely distributed in both Islands (Wellington, Nelson, Canterbury, Otago, Southland).

Allotype.—♀. Length, 10 mm.; wing, 11 mm.

Generally similar to female, differing chiefly in sexual characters. Antennae relatively short, about as long as thorax alone, scape and basal segment of flagellum ochreous, flagellum brownish-black. Scutal lobes conspicuously dark brown. Abdomen dark brown, the hypopygium obscure yellow, lobes of ninth tergite brownish-black. Male hypopygium (fig. 14) with ninth tergite produced medially, emarginate posteriorly, lateral lobes triangular, hairy. Basistyles relatively stout; dististyles two, both small; outer dististyle a small flattened blade that terminates in curved blackened spine, margin of blade setiferous; inner style much longer than outer, base enlarged and provided with coarse setae, distal portion slender, apex obtusely rounded, surface with microscopic setulae. Interbasal process chitinized, boomerang-shaped, narrow outer end subacute at apex. Aedeagus long and narrow, basal two-thirds with lateral wing, slender apical third gently curved. Gonapophyses appearing as very large flattened blades, almost transparent in mounts, outer apical angle produced caudad into more slender lobe that is obliquely truncated at apex.

Allotype, ♂, Ohakune, Wellington, altitude 2,060 ft.; 12th November, 1921 (*T. R. Harris*).

Limnophilella serotina (Alexander).

1922. *Limnophila serotina* Alexander, *Insec. Inscit. Menst.*, vol. 10, pp. 202–3.

The type, a female, was taken in the Riccarton (Deans) Bush, Christchurch, Canterbury, in April, 1922, by Gourlay. The fly is known only from Canterbury and Westland.

Allotype.—♂. Length, 11 mm.; wing, 12·4 mm.

Generally similar to female, but of more delicate, ethereal build, not unlike *L. delicatula* (Hutton), which I consider to be closely allied.

Characters as in female, differing as follows: Antennae of moderate length, about as long as combined head and thorax; scapal segments ochreous, flagellum dark brown, basal segments a trifle paler. Abdomen reddish-brown with dark-brown subterminal ring that includes segments 7 and 8. Male hypopygium (fig. 15) with basistyles relatively stout, with sparse relatively short setae; dististyles two, united at extreme base; outer style dilated into a wing on basal half, surface with microscopic setulae, apical half more narrowed and terminating in setiferous beak, before apex on outer margin with a broad flattened glabrous tooth; inner style a little shorter, of nearly uniform width throughout, apex obtuse. Gonapophyses appearing as conspicuous divergent horns. Aedeagus short and stout, the apex bifid.

Allotype, ♂, Punakaipe, Westland; 27th February, 1923 (*T. R. Harris*).

Cerozodia paradisea Edwards.

1923. *Cerozodia paradisea* Edwards, *Trans. N.Z. Inst.*, vol. 54, p. 328, pl. 30, fig. 93 (wing of ♂).

Edwards's types, males, were from the vicinity of Lake Wakatipu, Otago. The fly is known only from Otago and Southland.

Allotype.—♀. Length, 25 mm.; wing, 3·8 mm.

Characters as in male, differing as follows: Antennae 26-segmented, terminal two segments closely united and possibly to be interpreted as being a single segment; flagellar segments 1–13 with distinct branches, the longest about one-half longer than segments that bear them; flagellar segment 14 protuberant on lower face but not otherwise produced. Head yellowish-grey pruinose. Praescutal stripes three, light yellow, interspaces brown; scutellum and postnotum light grey. Halteres ochreous, knobs dark brown. Legs with coxae light-grey pruinose; legs with femora dark brown, tibiae and tarsi paler brown, terminal tarsal segments infuscated. Wings rudimentary, light brown, costal margin near base, and outer edge, darker brown. Venation distorted. Ovipositor with basal shield varnished, yellow, with longitudinal oblique brown markings. Tergal valves of ovipositor long and slender, gently upcurved.

Allotype, ♀, Hunter Range, near Lake Manapouri, Southland, altitude 4,000 ft.; 1st to 7th January, 1923 (*S. Lindsay*).

Gynoplistia pedestris Edwards.

1923. *Gynoplistia pedestris* Edwards, *Trans. N.Z. Inst.*, vol. 54, p. 317.

Edwards's type, a female, lacked exact data, but, since it was collected by Wakefield, was presumably from Canterbury. The discovery of this fly in large numbers by Campbell and Gourlay within the limits of the City

of Christchurch, as discussed in the appended account, indicates that the type-locality is very probable. The fly has not been taken elsewhere.

Allotype.—♂. Length, 14 mm.; wing, 2·5 mm.

Characters as in female, differing as follows: Antennae 16-segmented, formula being 2 + 2 + 8 + 4; basal pectinate segments in spiral alignment; pectinations short, the longest about three times length of segment that bears it. Head light grey, centre of vertex suffused with dark brown. Mesonotal praescutum pale brown, anterior end of median stripe and posterior ends of lateral stripes better indicated, brown, the latter passing on to scutal lobes; median area of remainder of mesonotum light grey. Pleura dusted with grey. Wings rudimentary, yellowish, more infuscated outwardly, without distinct pattern Abdomen reddish-brown, tergites with slightly darker median stripe and with dark-grey sublateral margin; sternites largely dark grey. Hypopygium reddish. Male hypopygium (fig. 16) with basistyle simple, stout, mesal face with abundant setae; mesal face at base with smooth hemiovate black lobe. Outer dististyle a flattened blade, broadest at base, apex on outer margin produced into conspicuous black spine, remainder of apex squarely truncated, not projecting beyond spine, margin weakly serrulate; outer dististyle without setae; inner dististyle slender, inner or mesal face near mid-length bulging and provided with setae, apex beyond this base slightly bent, provided with numerous setigerous punctures and with a short stout spinous seta on inner margin. Gonapophyses slender, before mid-length bent strongly upon themselves, tips weakly expanded. Aedeagus slender, straight, base dilated, apex bifid.

Allotype, ♂, Christchurch, Canterbury, altitude 30 ft.; 18th October, 1921 (*E. S. Gourlay*).

This is the only species of *Gynoplistia* so far described in which both sexes are nearly apterous. I am greatly indebted to Mr. Gourlay for the accompanying discussion of the conditions under which these flies were found.

"This little lot is the result of one half-hour's collecting at the locality indicated on the labels in the bottles. The flies are fairly plentiful on a hot day, and are not only like harvest-spiders (Phalangiidae) in appearance, but are also similar in their movements, each having the same peculiar springy gait. They delight in hanging on tall grass-blades without a movement, basking in the sun. Associated with this species to-day were two other Tipulidae, the relative abundance of the three being indicated by the following figures: *Gynoplistia pedestris*, 50 per cent.; *Limnophila skusei*, 35 per cent.; *Holorusia novarae*, 15 per cent. In their breeding-grounds the soil is a rich, black, peaty humus, and though wet is not slimy. The river (Avon) flows through the centre of the city and the locality is about five minutes' walk from the Square. This is the only locality from which I have collected this species [to which was later added Johnson's Fish-pond, Opawa, Christchurch—a single male on 12th February, 1922], and this particular stretch is about 100 yards long by 2·5 yards in width at its broadest point, so they seem to have a limited range. I have not observed particularly whether they are to be found in other similar places along the river, but no doubt this will be the case."—(*E. S. Gourlay*).

Gynoplistia sackeni Alexander.

1920. *Gynoplistia sackeni* Alexander, *Insec. Inscit. Menst.*, vol. 8, pp. 125–26.

The type, a male, was collected at Wellington in June, 1895, by Hudson. This interesting species has been taken only in the Province of Wellington. The fly appears to be a characteristic winter and early-spring species.

Allotype.—♀. Length, 14 mm.; wing, 4 mm.

Female differs from male chiefly in sexual characters. Antennae 16-segmented, basal eight flagellar segments with short branches, the longest not exceeding segment that bears it; lower face of ninth flagellar segment slightly produced. Basal segment of scape sparsely pruinose; second segment pale brown; flagellum black throughout. Mesonotal praescutum buffy, the colour largely concealed by three slightly darker stripes; remaining sclerites of mesonotum more pruinose. Wings greatly atrophied, as indicated by above measurements, being long and slender, strap-like, dark brown with base more yellowish. Venation distorted but recognizable. Tips of femora and tibiae narrowly infuscated; tarsi largely brown. Abdomen more or less pruinose, caudal margins of segments brighter brown. Ovipositor with valves very long and slender, especially the gently upcurved tergal valves.

Allotype, ♀, Ohakune, Wellington, altitude 2,060 ft.; 30th September, 1921 (*T. R. Harris*).

Gynoplistia fuscoplumbea Edwards.

1923. *Gynoplistia fuscoplumbea* Edwards, *Trans. N.Z. Inst.*, vol. 54, p. 318, pl. 35, fig. 165 (hypopygium).

Edwards's type, a male, was from Wellington, collected by Hudson. The fly is well distributed in the Province of Wellington.

Allotype.—♀. Length 15 mm.; wing, 11 mm.

Generally similar to male, differing as follows: Antennae 17-segmented, basal nine flagellar segments with short branches, the longest scarcely exceeding in length segments that bear them; basal segment of scape heavily pruinose; second segment ochreous at apex; flagellum with branches black. Rostrum and head grey, vertex infuscated on either side of pale median line. Praescutal stripes fairly well defined. Femoral subterminal pale rings faint to nearly obsolete. Wings fully developed, more yellowish than in male; wing-tip scarcely infuscated. Ovipositor with valves very long and slender, tergal valves gently upcurved.

Allotype, ♀, Ohakune, Wellington, altitude 2,060 ft.; 2nd December, 1922 (*T. R. Harris*). Taken *in copula* with male and pinned together.

Gynoplistia incisa Edwards.

1923. *Gynoplistia incisa* Edwards, *Trans. N.Z. Inst.*, vol. 54, pp. 318–19, pl. 35, fig. 166 (hypopygium).

Edwards's type, a male, was from Wellington, collected by Hudson. The species occurs in both Islands.

Allotype.—♀. Length, 16 mm.; wing, 12 mm.

Generally similar to male. Antennae 17-segmented, basal ten flagellar segments with relatively elongate branches, the longest being about one-half longer than segment that bears it; terminal five segments simple. Rostrum brownish-ochreous. Scapal segments of antennae ochreous; basal two flagellar segments pale basally, apex and branches brownish-black. Head dark grey, lighter behind antennal bases. Mesonotal praescutum with lateral stripes very distinct but median stripe barely indicated, as in male, faintly divided by median dark vitta. Subterminal orange annulus of femur paler and less conspicuous. Wings fully developed; apex not so heavily infuscated as in male. Ovipositor with tergal valves long and slender, especially the gently upcurved tergal valves.

Allotype, ♀, Ross, Westland; 19th February, 1923 (*T. R. Harris*).

Gynoplistia arthuriana Edwards.

1923. *Gynoplistia arthuriana* Edwards, *Trans. N.Z. Inst.*, vol. 54, p. 319, pl. 30, fig. 75 (wing).

Edwards's type was from Arthur's Pass, Canterbury, at 3,000 ft., collected by Hudson. The species is known only from this general region.

Allotype.—♀. Length, 11·5 mm.; wing, 10 mm.

Characters as in female, differing as follows: Antennae 17-segmented, the formula being 2+2+8+5, basal pectinate branches being in spiral alignment; longest branches between three and four times the length of segments that bear them. Head grey, vertex suffused with rich brown. Mesonotal praescutum with median stripe almost concolorous with ground-colour, margined laterally with brown; lateral stripes distinct. Abdomen dark brown, basal lateral region of individual tergites lighter brown. Male hypopygium (fig. 17) with caudal margin of ninth tergite very feebly concave medially. Basistyles relatively short and stout, simple, mesal face grooved, adjoining margins and apex on mesal face densely provided with long coarse setae that become small to obsolete on outer face at base of sclerite; a small pale unarmed tubercle on mesal face of sclerite at base. Outer dististyle a flattened blade; some distance before apex on outer face with a small black tooth; apex gently serrulate to crenulate; inner dististyle shorter, just beyond mid-length gradually narrowed to slender feebly setiferous apex. Gonapophyses closely subtending small curved aedeagus, each apophyse trifid at apex.

Allotype, ♂, Otira Gorge, Westland; 10th January, 1920 (*J. W. Campbell*).

Atarba (Atarba) viridicolor Alexander.

1922. *Atarba (Atarba) viridicolor* Alexander, *Ann. Mag. Nat. Hist.* (9), vol. 9, p. 308.

The type, a female, was taken by Harris at Ohakune in October, 1921. The fly is at present known only from this general region.

Allotype.—♂. Length, about 5·8 mm.; wing, 7·3 mm.; antennae, about 11 mm.

Generally similar to female, differing chiefly in sexual characters. Antennae very long, nearly twice length of body, elongate-cylindrical flagellar segments with numerous delicate erect setae distributed throughout their length. Green coloration of body is faded into a fawn-yellow, coxae remaining green. Abdominal tergites brown, sternites paler; a subterminal dark-brown ring. Male hypopygium (fig. 18) with basistyles very long and slender, surface setiferous, especially mesal face; immediately before apex on mesal face with low setiferous tubercle. A single dististyle, this very remarkable and suggestive of the origin of the double dististyli of most Tipulidae; style is a pale, curved blade, apex obtuse, just beyond mid-length on outer face with a slightly shorter densely spinous lobe; the appearance thus presented is much as though the two styli were originally a unit and were now in process of division. Interbasal process small, pale, apex truncate. Gonapophyses appearing as slender strongly curved horns, directed cephalad, thence mesad, caudad, and finally laterad in almost a circle. Aedeagus relatively short, twisted at base, apex obtuse.

The more widely distributed *Atarba (Atarba) filicornis* Alexander exhibits a very different type of hypopygium (fig. 19). Ninth tergite deeply emarginate posteriorly, the relatively slender lateral lobes thus formed being provided with long coarse setae. Basistyles shorter and stouter, subapical tubercle more slender; interbasal process very small. Dististyle

deeply split, outer arm a slender chitinized rod, apex acute, margin smooth or nearly so, except at base where is borne a very powerful bifid spine, with a tiny double spinule in its axil; inner arm of dististyle subequal in length, slender, pale, with sparse tiny setae. Aedeagus long, gently curved upward, with row of papillae along its face. Gonapophyses of either side bifid, tip of each arm densely tufted with golden spinous setae.

Allotopotype, ♂, Ohakune, Wellington, altitude 2,060 ft.; 13th November, 1921 (*T. R. Harris*).

Elephantomyia zealandica Edwards.

1923. *Elephantomyia zealandica* Edwards, *Trans. N.Z. Inst.*, vol. 54, p. 288, pl. 28, fig. 35 (wing).

Edwards's type, a female, was from Lake Wakatipu, Otago, collected in 1906 by Hudson. The fly is now known to be widely distributed in both Islands.

Allotype.—♂. Length, excluding rostrum, 5·5 mm.; wing, 6·5 mm.; rostrum alone, about 4 mm.

Similar to female, differing only in sexual characters. Median praescutal stripe very distinct on anterior half of sclerite, becoming obliterated behind. Abdomen with subterminal dark-brown ring, including segments 7 and 8. Male hypopygium (fig. 20) with basistyles stout, setiferous, more densely so on mesal face. Dististyles two, small, outer style a straight slender heavily chitinized rod slightly narrowed toward apex, which is weakly toothed; inner style a little longer and stouter, fleshy, apex slightly curved, surface setiferous. Gonapophyses almost transparent in balsam mounts, curved near mid-length, apex obtuse; besides this pair of apophyses are two other pairs on either side of base of aedeagus. Aedeagus stout, slightly coiled.

Allotype, ♂, Waipori, Otago, altitude 2,000 ft.; 5th December, 1921 (*W. G. Howes*).

Tribe TIPULINI.

Dolichopeza (Dolichopeza) atropos (Hudson).

1895. *Tipula atropos* Hudson, *Trans. N.Z. Inst.*, vol. 27, p. 295.

1900. *Dolichopeza atropos* Hutton, *ibid.*, vol. 32, p. 24, pl. 3, fig. 1 (wing).

1923. *Dolichopeza atropos* Edwards, *ibid.*, vol. 54, p. 331.

Hudson's unique type, a male, was taken at Terawhiti, near Wellington, while hovering about a cave (a gold-mining shaft, according to Edwards). Hutton redescribed the unique type. Edwards had not seen a specimen.

Allotype.—♀. Length, 15 mm.; wing, 15 mm.

Female agrees well with male, differing chiefly in sexual characters. Antennae nearly as long as thorax; basal segment of scape pale brownish-testaceous; second segment of scape light yellow; flagellum black; flagellar segments each with slight basal swelling provided with short verticils. Vertical tubercle conspicuous, entire, pale-fulvous, contrasting markedly with remainder of body. Mesonotal praescutum with a slightly paler stripe on either side of darker median line; short lateral stripes likewise paler than ground-colour. Ovipositor with short stout valves, tergal valves straight.

Allotype, ♀, Queenstown, Otago; 4th January, 1923 (*C. C. Fenwick*).

This is the largest of the four New Zealand species of the genus thus far described. The fulvous vertical tubercle was not mentioned in either

Hutton's or Hudson's descriptions. In order to be certain of the identity, specimens were submitted to Mr. Hudson, who very kindly compared them with his type and reports them identical.

Macromastix submontana Edwards.

1923. *Macromastix submontana* Edwards, *Trans. N.Z. Inst.*, vol. 54, p. 346.

Edwards's type, a female, was from Mount Cleughearn, in the Hunter Mountains, Southland, collected in 1916 by Philpott. An additional series from the same general locality was taken in January, 1923, by Stuart Lindsay.

Allotype.—♂. Length, 16 mm.; wing, 20 mm.

Agreeing closely with type female. Antennae short, black throughout, only 11-segmented; penultimate and antepenultimate segments small, terminal segment larger and nearly twice the length of preceding segment. The type female, which is in writer's collection through the kindness of Mr. Philpott, likewise has 11-segmented antennae as given by Edwards. Thoracic setae creamy-white. Basal half of abdominal tergite 2-deep fulvous-orange, narrowly divided medially by a black longitudinal vitta. Male hypopygium black, including dististyles. Ninth tergite with caudal margin emarginate.

Allotype, ♂, Hunter Range, near Lake Manapouri, Southland, altitude 4,000 ft.; 1st to 7th January, 1923 (*S. Lindsay*).

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—— 1922D. *New or Little-known Tipulidae (Diptera), VIII, *Ann. Mag. Nat. Hist.* (9), vol. 9, pp. 145–60.

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Descriptions of New Zealand Lepidoptera.

By E. MEYRICK, B.A., F.R.S.

Communicated by G. V. Hudson, F.E.S., F.N.Z.Inst.

[*Read before the Wellington Philosophical Society, 26th September, 1923; received by Editor, 10th October, 1923; issued separately, 28th August, 1924.*]

THE following species were received through the kindness of my friend Mr. G. V. Hudson, amongst other material generously sent for study.

TORTRICIDAE.

Tortrix orthocopa n. sp.

♂♀. 18-21 mm. Head, palpi, thorax whitish-ochreous. Forewings suboblong, costa in ♂ with moderate fold from base to ⅓, termen sinuate, hardly oblique; pale ochreous, sometimes tinged brownish; markings variably tinged lilac and edged with dark-brown streaks; edge of basal patch very oblique, on costal half obsolete; edges of central fascia nearly straight, very oblique, anterior from ¼ of costa to ⅔ of dorsum, posterior from beyond middle of costa to termen above tornus, sometimes a lighter spot edged posteriorly with one or two dark strigulae occupying anterior part of central fascia on costa; costal spot very faint, edged anteriorly by a very oblique brown striga, sometimes faintly continued sinuate to middle of termen: cilia pale ochreous, two brownish lines more or less marked. Hingwings, ♂ whitish-grey, ♀ ochreous-grey-whitish, a very few small cloudy greyish flecks; cilia concolorous.

Wellington, in January; four specimens. Between *tigris* and *torogramma*, but distinct from both.

Ochetarcha n. g.

Palpi rather slender, curved, ascending, with appressed scales, terminal joint extremely short. Thorax with posterior crest. Forewings, 2 from before ⅔, 3 from angle, 7 to termen. Hindwings without cubital pecten; 3 and 4 connate, 5 approximated, 6 and 7 short-stalked.

Type, *miraculosa* Meyr. Having received a second example of this, I find that veins 6 and 7 of hindwings have a well-developed common stalk; this stalk is really present also in the first specimen, but so extremely short that I overlooked it. Hence the species cannot be referred to *Olindia*, and requires a new genus.

Ochetarcha miraculosa Meyr.

The second specimen has the upper part of the dark arched marking of forewing absent, so that the arch is represented by two fasciate streaks from dorsum rather converging, the anterior reaching ⅔ across wing, the posterior ½.

OECOPHORIDAE.

Borkhausenia idiogama n. sp.

♂♀. 15–16 mm. Head and thorax bronzy-grey, orbits in ♂ pale-yellowish. Palpi grey, in ♂ suffused pale-yellowish towards base, apex of second joint whitish. Antennal cilation of ♂ 1. Abdomen dark grey, in ♂ anal tuft and exserted genitalia whitish-ochreous, in ♀ a short whitish-ochreous scale-tuft beneath from praeanal segment, ovipositor exserted,

filiform. Forewings light grey, irregularly and suffusedly irrorated ochreous-whitish or light yellow-ochreous, especially posteriorly, a few scattered dark-grey scales; plical stigma blackish-grey, beneath it in ♀ an oblique spot of whitish suffusion; an inwardly-oblique streak of dark-fuscous suffusion from tornus, its apex indicating second discal stigma: cilia pale grey, suffusedly mixed or mostly suffused pale ochreous-yellowish. Hindwings dark grey; cilia grey.

Mount Egmont, in January; three specimens.

Atomotricha prospiciens n. sp.

♂. 20 mm. Head and thorax ochreous-whitish, shoulders more ochreous. Palpi ochreous-whitish, towards base irrorated dark fuscous. Forewings elongate, termen very obliquely rounded; ochreous-whitish partially suffused pale yellow-ochreous and sprinkled fuscous, dorsal area more whitish; a thick streak of dark-fuscous suffusion from base of costa along fold to near middle of wing, with a blackish dot at its apex and one on its lower edge at $\frac{1}{4}$ of wing, fold beyond this suffused white to near tornus; discal stigmata represented by circles of brown suffusion of which upper half is mixed blackish, these connected by a curved white streak, beyond second a blotch of white suffusion, above and before second some fuscous suffusion extending to costa; a dark-fuscous line from near costa at $\frac{3}{4}$ to near tornus, angulated in middle and zigzag above this, connected with costa by a spot of brownish suffusion; some brownish suffusion along upper part of termen: cilia whitish-ochreous, base white. Hindwings and cilia ochreous-whitish.

Dunedin, in December (taken by C. E. Clarke); one specimen. Next *isogama*.

TINEIDAE.

Rhathamictis n. g.

Head loosely rough-haired; ocelli posterior; tongue absent. Antennae $\frac{1}{2}$, in ♂ moderately ciliated, basal joint short, with slight pecten. Labial palpi moderate, porrected, second joint rough-scaled beneath, terminal joint short, loosely scaled, obtuse. Maxillary palpi short, slender, 3-jointed, folded laterally. Posterior tibiae rough-scaled above. Forewings 2 from $\frac{2}{3}$, 3 from angle, 7 to termen, 8–10 approximated, 11 from before middle. Hindwings 1, elongate-ovate, cilia $\frac{3}{4}$; 2–7 tolerably parallel.

An interesting form, probably aculeate and allied to *Lampronia*.

Rhathamictis perspersa n. sp.

♂. 14 mm. Head, palpi, and thorax grey. Forewings elongate, apex rounded-obtuse, termen obliquely rounded; dark purple-grey; scattered whitish-ochreous dots and strigulae—viz., about 7 transverse strigulae from costa, several in disc, a dot at apex, and about 15 small irregular dots in dorsal area: cilia purplish-coppery. Hindwings dark purple; cilia grey.

Wellington, in March; one specimen.

NEPTICULIDAE.

Nepticula progama n. sp.

♀. 5 mm. Head white, occipital hairs yellowish. Thorax white, dorsally irrorated blackish and grey. Forewings white; basal fourth irrorated grey and blackish; irregular pale-grey costal and dorsal blotches irrorated blackish beyond middle, meeting in disc; an apical greyish blotch irrorated blackish, leaving apex itself whitish: cilia whitish-grey, round apex whitish, basal half sprinkled blackish. Hindwings and cilia grey.

One specimen, "locality uncertain," but apparently very distinct.

Notes and Descriptions of New Zealand Lepidoptera.

By ALFRED PHILPOTT, Assistant Entomologist, Cawthron Institute.

[*Read before the Nelson Philosophical Society, 10th October, 1923; received by Editor, 18th October, 1923; issued separately, 28th August, 1924.*]

As the present paper describes several obscure species, it has been thought advisable to figure not only the male genital structures of the new species, but also those of some closely related forms. The characters of the lepidopterous genitalia have not been previously used to any extent in the discrimination of species in New Zealand; it may be useful, therefore, to give a brief account of the methods of procedure.

Owing to the fact that the genital armature is usually more or less withdrawn within the preceding segments, and, where protruding, is frequently hidden beneath a covering of scales, it is of little use attempting the examination of dry material. It is necessary to remove the whole, or the apical portion, of the abdomen, and to soften and clear the parts. This is a very simple process and takes but little time. If the abdomen be gently levered upwards with a pin or dissecting-needle it will usually break off readily at its junction with the thorax. If it is desired to remove the apical portion only, the severance can be effected with a pair of very fine scissors, those with the blades curved round being the most suitable. In order to avoid the danger of the severed piece flying off and being lost, it is advisable to moisten the abdomen with spirit. When the desired part is secured it is placed in a small porcelain crucible with some 10-per-cent. solution of caustic potash and boiled for a minute or two. This dissolves the fatty parts, muscles, &c., and leaves the chitinous organs clearly displayed. For examination the object is removed to a watch-glass and immersed in glycerine. It can be studied at once, but where drawings are desired it is better to allow it to soak in the glycerine for a day or so. A lateral view of the genitalia *in situ* and an inside view of one of the valvae are usually all that is necessary for descriptive purposes, but it is sometimes advisable to secure a dorsal view of the ninth tergite (upper part of the tegumen); the most desirable aspects will vary with the genus or family to which the species under consideration belongs.

NOCTUIDAE.

Melanchra furtiva n. sp. (Fig. 1, B.)

♂♀. 36–40 mm. Head whitish mixed with ferruginous. Palpi ferruginous sprinkled with white, terminal segment ochreous. Antennae, stalk pinkish-white, bipectinations moderate, slightly longer than in *M. mutans* (Walk.), dark fuscous. Thorax with moderate anterior crest, whitish, densely mixed with pink; a Λ-shaped anterior line dark ferruginous margined behind with white; tegulae margined outwardly with deep ferruginous. Abdomen greyish-ochreous, pinkish laterally and posteriorly. Legs and under-parts ochreous-white densely mixed with pinkish. Forewings moderately dilated, costa almost straight, apex obtuse, termen obliquely rounded; pale pinkish-brown; markings blackish-ferruginous; veins strewn with white and dark scales; a submedian basal streak, slightly

sinuate and pointed, reaching about half-way to claviform; stigmata not prominent, obscurely pale-margined within, shape normal but orbicular rather large; traces of transverse lines, in the form of double dark strigulae, on costa at base, ⅓, and middle; an obscure waved pale subterminal line, irregularly dark-margined anteriorly, above tornus the margining being produced into a prominent streak; veins in subterminal area clearly dark-marked; three white dots on apical ⅓ of costa; a thin dark terminal line; fringes pink mixed with ochreous and white. Hindwings fuscous-grey, ochreous-tinged; fringes ochreous mixed with ferruginous and white, except on basal line.

The female differs in having the ground-colour white with only a trace of pink suffusion.

This species has previously been confused with *M. mutans* (Walk.), and, as far as markings go, there is little to separate the two. But the ground-colour is constantly different and the antennal pectinations are longer in the first species. Reference to the figures will show that the valvae of the two forms exhibit good differentiating characters.

The species appears to occur in mountainous localities from 1,000 ft. to 4,000 ft. A good series was taken on the Mount Arthur tableland in December, and in the Wakatipu district examples have been secured at Ben Lomond, Elfin Bay, Lake Luna, and Lake McKenzie in the months of November and December. Holotype (♂), allotype (♀), and a series of paratypes in coll. Cawthron Institute.

TORTRICIDAE.

Capua intractana (Walk.), *Char. Het.*, p. 83 (1869).

This Australian species must now be placed on the New Zealand list. During February and March, 1923, nine or ten of each sex were taken at light. The species is small and obscure, but (owing to its habit of coming to light) it is hardly likely to have been passed over if it had previously occurred in any numbers. In Australia *C. intractana* is widely distributed, being found in Queensland, New South Wales, Victoria, and South Australia. A short description is appended, which may assist New Zealand lepidopterists to recognize the species.

♂, 11–13 mm.; ♀, 14–17 mm. Forewings rather broad, costa strongly arched, termen straight, oblique; dull brown mixed with ochreous, especially in female; costal patch in male small, ochreous, confined to costal half and frequently obsolete; in female dark brown, margin obliquely outwards to above middle, thence angled sharply inwards; following this is an ochreous fascia, dilated dorsally, usually absent in male; a subterminal ochreous fascia, triangularly dilated, on upper half. The markings are often indistinct and frequently absent. Hindwings fuscous-grey with paler mottling.

Epichorista abdita n. sp. (Fig. 2, D and E.)

♂. 11½–13 mm. Head, palpi, and thorax bright reddish-ochreous. Antennae in male ciliated, 1¼. Abdomen dark fuscous. Legs ochreous-whitish, tarsal segments annulated with fuscous. Forewings, costa strongly arched at base, apex rectangular, termen very slightly oblique, rounded beneath; bright ochreous-reddish; markings very obscure; five or six fuscous dots on basal half of costa; traces of some leaden-white fasciae at ⅓; apical half of wing with numerous obscure waved leaden-white

fasciae, visible only under magnification; central fascia indicated by a clear reddish area on costa at middle: fringes ochreous-reddish, tips paler. Hindwings dark fuscous: fringes greyish-fuscous, with basal band and the tips round termen tinged with ochreous.

In one example the markings are quite obsolete and the ground-colour is much paler.

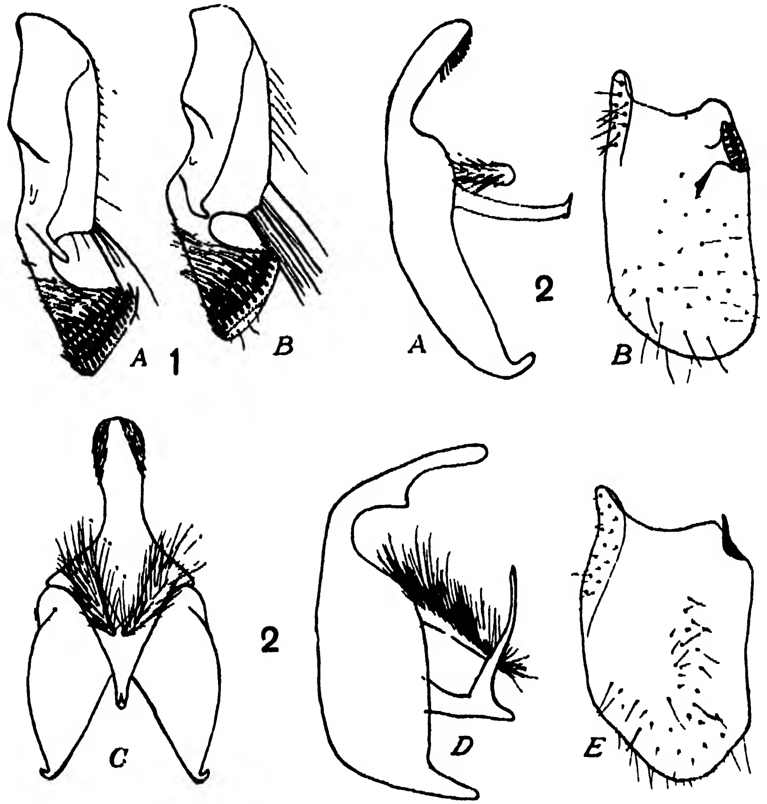


FIG. 1.—A. *Melanchra mutans* (Walk.). Inner view of valva.
B. *Melanchra furtiva* n. sp. Inner view of valva.
FIG. 2.—A. *Epichorista emphanes* (Meyr.). Lateral view of tegumen. B. Inner view of valva. C. Ventral view of tegumen.
D. *Epichorista abdita* n. sp. Lateral view of tegumen. E. Inner view of valva.

Superficially very like some varieties of *E. emphanes* (Meyr.), but a smaller and duller species; the longer antennal ciliations form a good distinguishing structural character.

Mount Arthur tableland, during the first week in March. Five males taken in open country at an elevation of 4,500 ft. Holotype (♂) and three paratypes in coll. Cawthron Institute.

GELECHIIDAE.

Gelechia neglecta n. sp.

♂. 10–13 mm. Head and thorax ochreous-white. Palpi ochr whitish, more or less infuscated. Antennae bronzy-fuscous. Ab

ochreous-whitish, brassy-yellow on anterior segments. Legs whitish-ochreous, anterior and middle pairs infuscated. Forewings lanceolate; ochreous-whitish; a ferruginous suffusion along fold, sometimes extended to before apex, sometimes absent; area beneath fold usually clearer white: fringes greyish-ochreous. Hindwings and fringes pale fuscous-grey.

An obscure species, but not easily confused with any other; it is the smallest yet described.

Cobb Valley, in December. Five males among rough herbage. Holotype (♂) and three paratypes in coll. Cawthron Institute.

Stomopteryx simplicella (Walk.), Tin., 1024; Meyrick, *Proc. Linn. Soc. N.S.W.*, vol. 29, p. 305, 1904. (Fig. 3, A, B, and C.)

This common Australian species is now established in New Zealand. Several specimens have been taken at Nelson, the dates varying from February to April. Mr. Meyrick, to whom I am indebted for the identification, informs me that the species is common throughout the southern half of Australia and also in Tasmania. I give below a brief description.

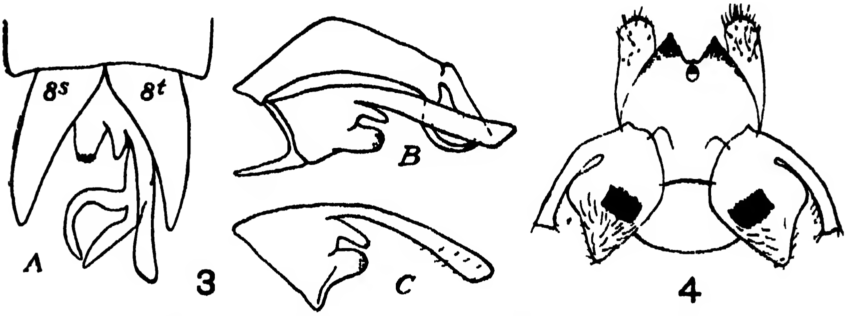


FIG. 3.—A. *Stomopteryx simplicella* (Walk.). Lateral view of genitalia: 8^s = eighth sternite; 8^t = eighth tergite. B. Lateral view of gentalia, eighth segment removed. C. Inner view of valva.
FIG. 4.—*Mnesarchaea similis* n. sp.: Inner view of genitalia (drawn under cover slip).

♂ ♀. 9–11 mm. Head shining pearly-grey. Palpi ochreous-white, terminal segment blackish outwardly. Antennae dark greyish-fuscous. Thorax shining grey. Abdomen shining grey, anal tuft ochreous. Legs whitish-ochreous, more or less infuscated. Forewings lanceolate, grey sprinkled with dark fuscous, especially on apical half; usually an irregular whitish spot on costa at ⅔; plical stigma elongate, dark fuscous, sometimes absent: fringes greyish-fuscous sprinkled with blackish-fuscous. Hindwings with apex produced, termen rounded beneath; pale greyish-fuscous: fringes uniformly fuscous-grey.

GLYPHIPTERYGIDAE.

Simaethis tillyardi n. sp.

♀. 17½ mm. Head and thorax white mixed with pale fuscous. Palpi, second segment strongly tufted beneath, white mixed with fuscous, terminal segment white mixed with black. Antennae black annulated with white. Abdomen bronzy-fuscous, suffusedly annulated with whitish. Legs whitish mixed with bronzy-fuscous, apices of tibiae and tarsi annulated with white.

Forewings moderate, costa hardly arched, apex pointed, termen markedly sinuate, oblique; pale bronzy-fuscous mixed with dark fuscous; markings snow-white; a small basal patch; a broad band before middle, projecting outwardly in disc and touching following band; an outwardly-oblique fascia from costa beyond middle, coalescing in disc with broad band at ¼ and terminating on tornus; a terminal band, dilated at apex; in the dark-fuscous discal area and above dorsum at ¾ are a few shining steel-blue scales: fringes on termen pale bronzy-fuscous with three white lines, on costa darker fuscous with median white line. Hindwings greyish-fuscous; apical ⅓ suffusedly white: fringes fuscous; a broad median band and tips white.

Very distinct; from the breadth of the white band the general effect is that of a white species with narrow fuscous fasciae.

A single female taken in March by Dr. R. J. Tillyard on Mount Cook at an altitude of 2,500 ft. Type in coll. Cawthron Institute.

MNESARCHAEIDAE.

Mnesarchaea similis n. sp. (Fig. 4.)

♂. 11 mm. Head white. Palpi white with a few brown scales on second segment. Antennae dull ochreous. Thorax pale ochreous, mixed with fuscous anteriorly. Abdomen fuscous-grey. Legs greyish-fuscous, tarsi annulated with ochreous-white. Forewings lanceolate, costa moderately arched, apex acute, termen straight, very oblique; ochreous-whitish, densely irrorated with bronzy and dark fuscous on apical half; a broad stripe of bronzy-fuscous along basal half of costa, its apex angled obliquely downwards towards tornus and extending across wing; a large subtriangular blotch of white or ochreous-white on costa following apex of costal stripe; an ochreous stripe along dorsum enclosing a dark-fuscous blotch at ⅔; a white striga from costa at about ⅚, margined posteriorly with black; a narrow white line between this and apex; a black band along termen, interrupted with white scales: fringes pale bronzy; a black spot opposite apex followed by white tips and some white tips about middle of termen. Hindwings fuscous with purplish reflections: fringes bronzy-fuscous.

Very similar to *M. hamadelpha* Meyr. in colour and markings, but a slightly larger and darker insect; the genitalia offer very distinct characters.

Mount Arthur tableland (4,500 ft.), in December; Cobb Valley (2,800 ft.), also in December; and Flora River (3,250 ft.), in January. A few male specimens from each locality. Holotype (♂) and paratypes in coll. Cawthron Institute.

MICROPTERYGIDAE.

Sabatinca aemula n. sp. (Fig. 5, C and D.)

♂♀. 11–12 mm. Head and thorax reddish-ochreous. Palpi ochreous. Antennae dark fuscous, basal fifth (in ♀ basal third) ochreous. Abdomen greyish-fuscous. Legs ochreous, last tarsal segment fuscous. Forewings ovate-lanceolate, costa strongly arched basally, apex acute, termen very oblique, slightly sinuate; shining ochreous, darker on apical half and above dorsum at base; a silvery-white fascia from costa at middle; irregular and variable in shape, sometimes spot-like, sometimes reaching middle of wing where it touches an irregular black spot; a similar but usually broader fascia at ¾, also connecting with a black (generally transverse) spot; sometimes a silvery-white dot or dots between second fascia and apex; a series of silvery-white spots round termen: fringes reddish-ochreous with

a very obscure dark basal line. Hindwings fuscous-violet: fringes, fuscous on basal half of dorsum, ochreous with a fuscous basal line on remainder of wing.

This and the following species are superficially very similar to *S. chrysargyra* (Meyr.). The present form is a rather larger insect and has less whitish suffusion. Good structural differences are to be found in the genitalia.

Cobb Valley, in December. Common among rough herbage and undergrowth at a damp spot on the edge of the forest. A single specimen taken also on the Mount Arthur tableland at an elevation of about 4,000 ft. Holotype (♂), allotype (♀), and a series of paratypes in coll. Cawthron Institute.

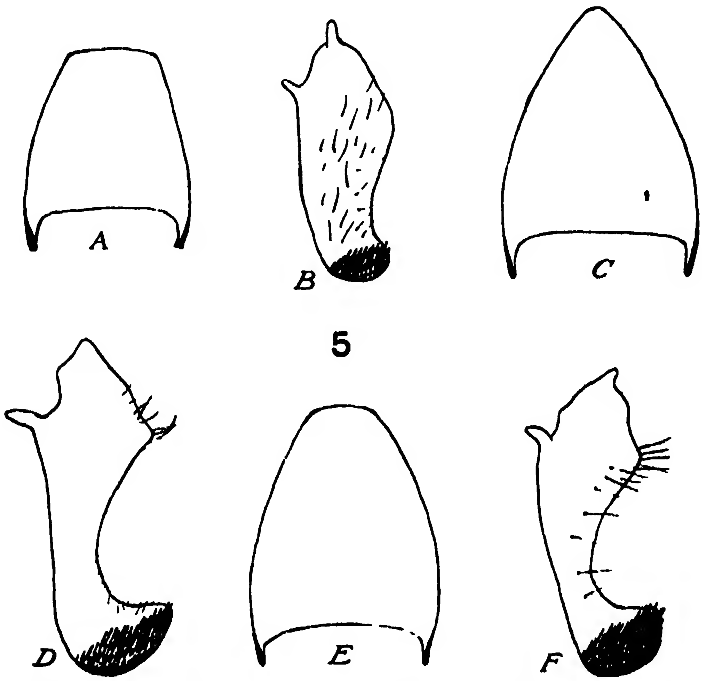


FIG. 5.—A. *Sabatinca chrysargyra* (Meyr.). Dorsal view of ninth tergite (upper half of tegumen). B. Inner view of valva.
C. *Sabatinca aemula* n. sp. Dorsal view of ninth tergite. D. Inner view of valva.
E. *Sabatinca aurantiaca* n. sp. Dorsal view of ninth tergite. F. Inner view of valva.

Sabatinca aurantiaca n. sp. (Fig. 5, E and F.)

♂♀. 10½–12½ mm. Head, palpi, and thorax ochreous. Antennae fuscous, basal ⅛ (in ♀ basal ⅓) ochreous. Abdomen greyish-fuscous. Legs ochreous, tarsi annulated with fuscous. Forewings ovate-lanceolate, costa strongly arched basally, thence straight, apex acute, termen very oblique, slightly sinuate; reddish-ochreous; a silvery-white irregular fascia from costa at ⅓, sometimes reaching across wing; a similar fascia at ⅔, expanding into a blotch on costa; two silvery-white spots on costa between ¾ and apex; five or six interrupted blackish fasciae between ⅓ and apex, forming

prominent spots on costa, termen, and dorsum: fringes reddish-ochreous. Hindwings fuscous-violet: fringes fuscous. mixed with ochreous round apex.

The species may be separated from both *chrysargyra* and *aemula* by the dark apical strigae and the general darker colouring; the genitalia of the male show sufficiently definite differentiating characters.

Dun Mountain, Nelson. Five specimens taken in November and December in forest at elevations of from 1,000 ft. to 2,500 ft. Holotype (♂), allotype (♀), and three paratypes in coll. Cawthron Institute.

A Method of Injecting the Tracheae of Insects.

By H. B. KIRK, M.A., F.N.Z.Inst., Professor of Biology, Victoria University College, Wellington.

[*Read before the Wellington Philosophical Society, 24th December, 1923; received by Editor, 31st December, 1923; issued separately, 28th August, 1924.*]

THE following method of injecting the tracheae of insects is so simple and obvious that I find it hard to suppose that it is new. I cannot, however, find any mention of it, nor can I find any one that is acquainted with it.

Prepare metagelatine in the usual way, by adding ammonia to a gelatine solution and keeping the solution melted for some hours until, on cooling, it does not set. Add a solution of carmine, and pass the mixture through a thin filter-paper. Place the mixture in a small beaker or other vessel, and put the insect (killed by chloroform to which amyl-nitrite has been added) in the mixture, submerging it by means of a disc of perforated zinc or otherwise. Set the beaker in a desiccator fitted with an exhaust-tube. It is desirable that it should also have a stop-cock. Exhaust by means of a suction-pump. When the desiccator is as completely exhausted as possible, stop the pump and reopen the stop-cock a very little, allowing the air to enter slowly. The pressure of the air, of course, forces the mixture into the exhausted tracheae. The advantage of the stop-cock is that the pressure is not restored all at once, and thus the mixture has time to reach the finer tracheae.

Remove the insect, and at once make a slit in the body-wall to permit the access of liquid to the peri-visceral spaces. Place the insect in acid alcohol of 70 or 75 per cent. in order to set the gelatine and precipitate the carmine. Dissection may be made in twenty-four hours. If the operation has been successful, not only will the main tracheae and the air-sacs be filled, but the finer tracheolae as well. Unless much time has been lost before immersion of the insect in acid alcohol, the colouring-matter will not have diffused through the tracheal walls.

In the case of adult lepidopterous insects it may happen that one or more of the stigmata become closed by loose scales, so preventing the inflow of the gelatine mixture.

Among other applications of the method is the filling of the lungs of air-breathing vertebrates in case it is desired to obtain a cast of the lung-cavity.

New Zealand Hydroptilidae (Order Trichoptera).

By Martin E. Mosely, F.E.S.

Communicated by R. J. Tillyard, M.A., D.Sc.

[*Read before the Nelson Institute, 19th December, 1923; received by Editor, 31st December, 1923; issued separately, 28th August, 1924.*]

New Zealand Hydroptilidae have attracted little attention, and only one species, *Oxyethira albiceps* McL., has been described. Even for this species the description is incomplete, as no drawings of the genitalia have hitherto been published.

A year or two ago Mr. Jack Henderson sent home a dozen or so of these little insects, and it was at once apparent that *O. albiceps* was by no means the only representative of New Zealand Hydroptilidae; and in a small collection sent me from the Cawthron Institute, Nelson, by Dr. R. J. Tillyard, with the request that I should describe any new material that I might find included in it, I found that there was, besides *O. albiceps*, at least one species distinct from those which Mr. Henderson had sent.

Three species form a group by themselves, and, although they have certain characters resembling those of *Oxyethira*, yet they differ consistently in other respects, and furnish material for a new genus, described as follows:—

Paroxyethira n. g.

Spurs 0, 3, 4. Ocelli present. Head furnished posteriorly with two large lobes or caps. Antennae in ♂ with 32 to 41 joints, according to species. Palpi as in *Oxyethira*. Wings long and slender, apices very acuminate and generally furnished with tufts of white and also black hairs. In both anterior and posterior wings the sector (according to MacLachlan's nomenclature) is forked twice and upper branch of cubitus once, as shown in fig. 1.

Abdomen of ♂ having terminal dorsal segment excised with a wide deep U-shaped excision extending nearly to base of segment, exposing the penis in the cavity thus formed, and in one species a complicated arrangement of asymmetric, strongly chitinized teeth.

Superior appendages with apices directed towards each other and generally concave. From base of seventh ventral segment arises a process either broad and short or long and slender, according to species, and thickly covered with hairs. Sixth ventral segment armed with a tooth.

Abdomen of the ♀ resembling *Oxyethira*.

Paroxyethira tillyardi n. sp. (Figs. 2, 3, 4, 5.)

Length of anterior wing, ♂, 3·5 mm.

Antennae about 36-jointed in ♂; last dorsal segment excised as above; superior appendages very short, armed at extremities each with a short blunt finger-like tooth, directed inwards. In dorsal cavity can be seen, in balsam preparation, a series of strongly chitinized hooks, most of which are grouped on right side of cavity with blackened apices directed towards

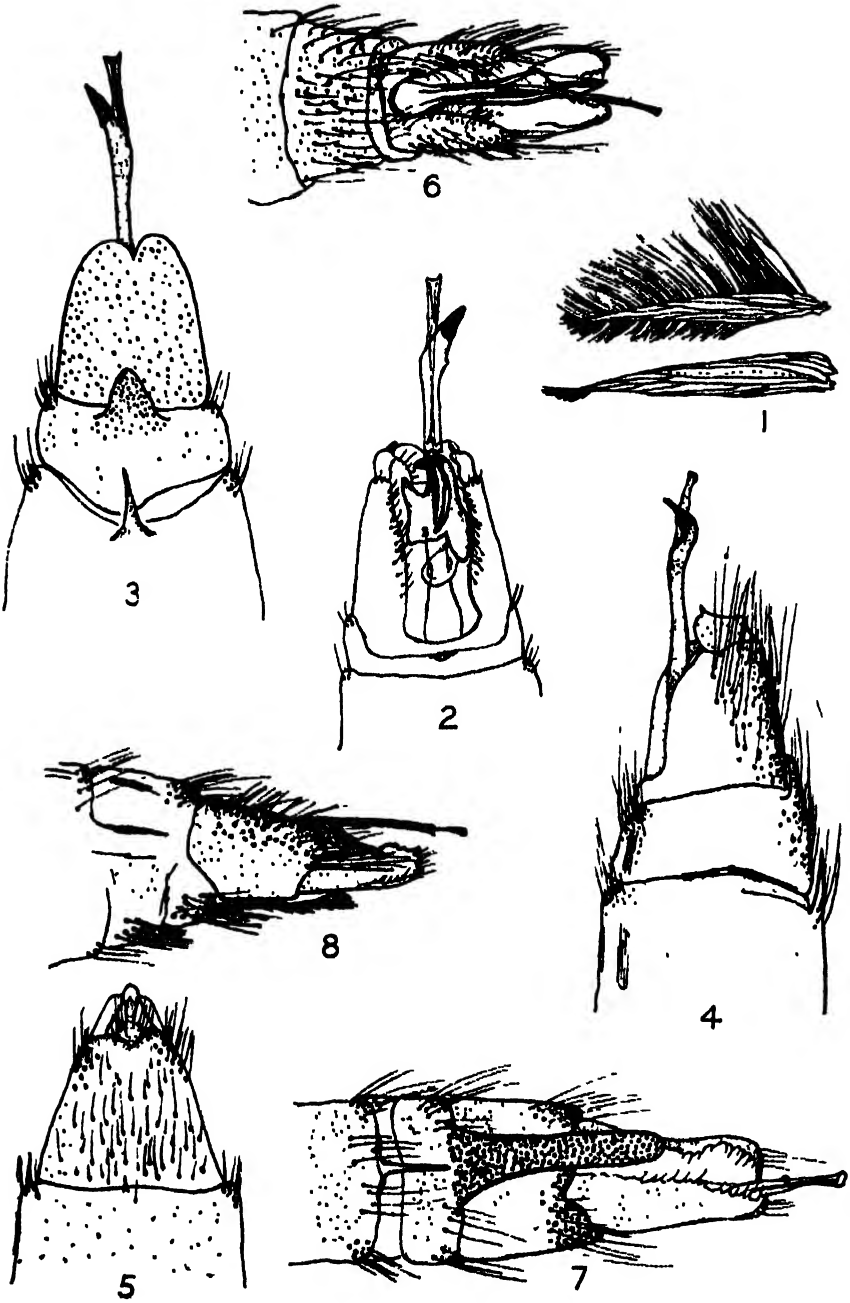


FIG. 1.—Wings of *Paroxyethira tillyardi*, ♂.
FIG. 2.—*P. tillyardi*, ♂, dorsal. Portion of penis removed between A and B.
FIG. 3.—*P. tillyardi*, ♂, ventral.
FIG. 4.—*P. tillyardi*, ♂, from the side.
FIG. 5.—*P. tillyardi*, ♀, ventral.
FIG. 6.—*P. hendersoni*, ♂, dorsal.
FIG. 7.—*P. hendersoni*, ♂, ventral.
FIG. 8.—*P. hendersoni*, ♂, from the side.

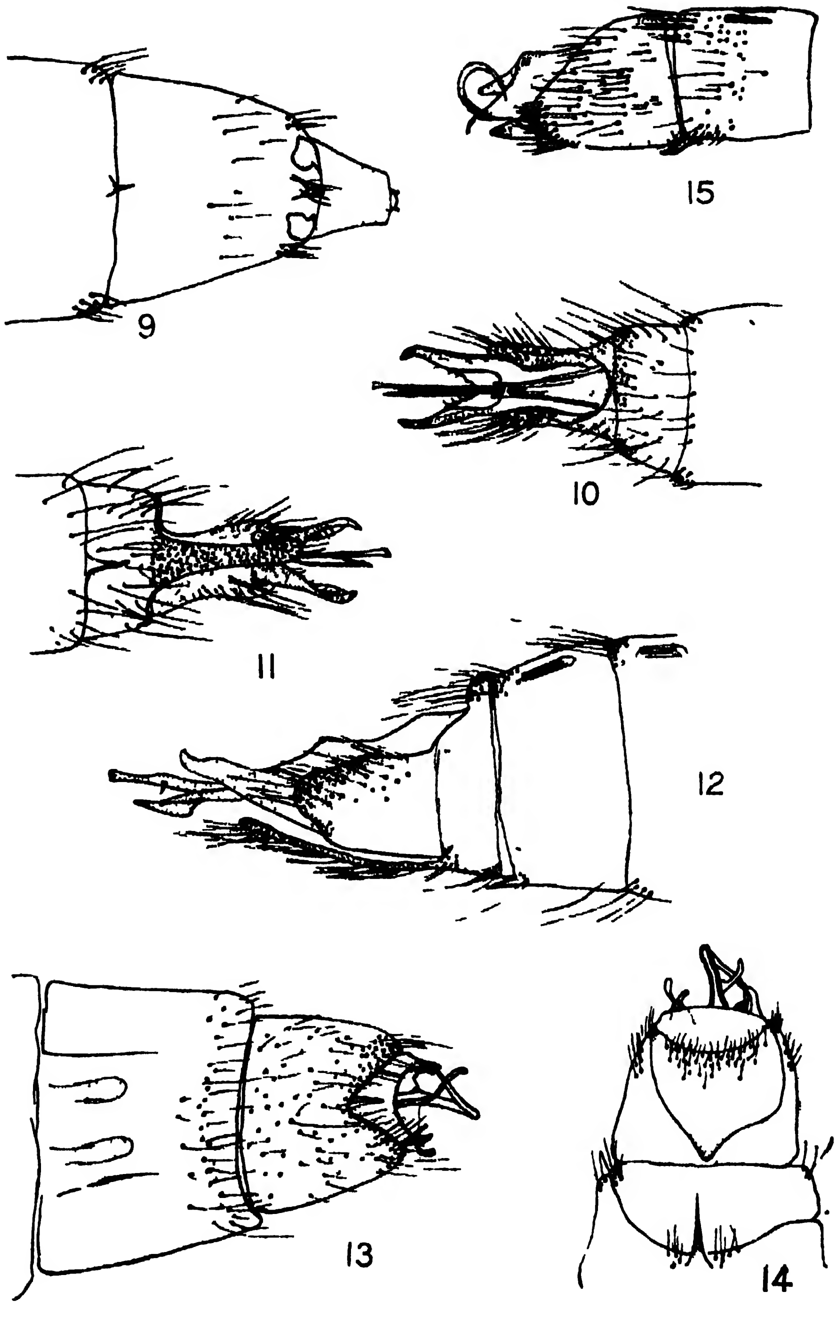


FIG 9.—*P. hendersoni*, ♀, ventral.
FIG 10.—*P. eatoni*, ♂, dorsal.
FIG 11.—*P. eatoni*, ♂, ventral
FIG. 12.—*P. eatoni*, ♂, from the side

FIG. 13.—*Oxyethira albiceps*, ♂, dorsal.
FIG 14.—*O. albiceps*, ♂, ventral
FIG 15.—*O. albiceps*, ♂, from the side

left; penis in all examples before me much exserted, and bearing a strong blackened tooth towards apex; process of seventh ventral segment short and broad; tooth on sixth ventral segment long and slender.

In ♀ the abdomen is stout, the last ventral segment deeply excised. There is a short tooth on penultimate segment.

Habitat.—Tarawera, North Island, New Zealand; 12th November, 1919. Cawthron Institute collection.

Paroxyethira hendersoni n. sp. (Figs. 6, 7, 8, 9.)

Length of anterior wing, ♂, 3 mm.

Antennae about 41-jointed in ♂. Last dorsal segment excised as above; superior appendages long, broad, and concave; lower edges armed with numerous teeth. Towards their bases are two slender hooks curved over penis-sheaths, which are strongly bent downwards before apices; penis long and slender, with a small hook some distance below apex; ventral process of seventh segment very long and spatula-shaped, with blunt rounded apex.

In ♀ the abdomen is stout and at base of seventh ventral segment are two strongly chitinized plates bent over and directed towards each other.

Habitats.—River Tekapo, Mackenzie County, South Island, New Zealand; 24th January - 3rd February, 1922: in my collection. Spreydon, South Island, New Zealand; October, 1919: Cawthron Institute collection. Arthur's Pass, South Island, New Zealand: 16th January, 1920: Cawthron Institute collection.

Paroxyethira eatoni n. sp. (Figs. 10, 11, 12.)

Length of anterior wings, ♂, 3 mm.

Antennae about 33-jointed in ♂. Last dorsal segment excised as above; superior appendages concave, long and slender; upper margins gradually dilated below apices and curving inward; lower margins armed with teeth and strong hairs; penis long and slender, with small hook some distance below apex; penis-sheaths long and strongly chitinized, extending nearly whole length of penis; process of seventh ventral segment as in *P. hendersoni*; tooth on sixth ventral segment short.

Female unknown.

Habitat. River Tekapo, Mackenzie County, South Island, New Zealand; 24th January 3rd February, 1922. In my collection.

Oxyethira albiceps McL. (Figs. 13, 14, 15.)

As no figure of the genitalia has hitherto been published, I include amongst these descriptions drawings from the single ♂ that I have before me. I am not altogether satisfied with these figures, as the balsam preparation has become very transparent and the various parts are somewhat obscure. The lateral aspect is a freehand sketch.

Habitat.—Spreydon, South Island, New Zealand. Bred by G. V. Hudson. Cawthron Institute collection.

In conclusion, I must express my thanks to Mr. Kenneth J. Morton, who kindly read through and verified the above descriptions.

The Leaf-mining Insects of New Zealand: Part 5 — The Genus Nepticula *(Lepidoptera), and the Agromyzidae (Diptera) continued, and* Gracilaria selenitis *Meyr. (Lepidoptera).*

By Morris N. Watt, F.E.S.

[Read before the Wanganui Philosophical Society, 5th November, 1923; received by Editor 31st December, 1923; issued separately, 28th August, 1924.]

Plates 67, 68.

(27.) Nepticula lucida Philp. (The Beech-nepticulid).

Nepticula lucida Philp., *Trans. N.Z. Inst.*, vol. 51, p. 225, 1919; vol. 53, p. 197, 1921.

The Imago.

Philpott's Original Description.—See *Trans. N.Z. Inst.*, vol. 51, p. 225, 1919.

Type in Mr. C. Clark's collection, Dunedin.

General Notes.—There is very little variation in this moth. During the past season a series of several hundred was reared. The white band at ⅗ is formed by junction of apices of two triangular areas—one on dorsum (the larger), one on costa; dorsal area together with its fellow on opposite wing form a well-marked diamond saddle on back when moth is in resting position. In a few specimens the dorsal and costal spots were not united, and in one both were wanting. Anterior three-fifths of forewing is shining dark grey with bronzy reflections viewed in bright light; apical two-fifths densely irrorated with black scales, and there is a distinct black cilial line. Head light yellowish-brown, basal joint of antenna and eyecap white. Thorax dark grey. Ventral surface of abdomen, and legs silver-grey. Wing-shape similar, though smaller, to *N. perissopa*, and venation the same as in species already described. Flight erratic and fast, and if a resting moth be disturbed it will run and jump with considerable activity.

Distribution.

So far this beautiful Nepticulid has been found in only one very restricted locality, on the banks of Waitati Stream, about five miles from Waitati (Dunedin). Considering the wide distribution of the food-plant, the moth should be found in other localities, and careful searching at the right time will no doubt bring it to light. Originally found by Mr. Clark on 7th December, 1919, by beating imagines from birch-trees. The locality was visited on 13th November, 1920, but neither mines nor imagines were found. On 20th August, 1921, large numbers of mines, larvae, and pupae were obtained; on some branches about 6 ft. from ground almost every leaf was infected. A large number of actively-mining larvae were secured and placed in breeding-jars; most had spun their cocoons and pupated by 30th August, 1921; first imagines emerged 22nd September, and others continued emerging till 26th October, the greatest number emerging during first week of October. A visit to the locality on 23rd October revealed only a few active larvae.

Food-plant.

The silver southern-beech. *Nothofagus Menziesii* (tawhi, tawai), known variously as "brown-birch," "red-birch," "white-birch," and "silver-birch," a tall evergreen forest-tree with small tough serrate leaves, occurring usually in subalpine belt throughout South Island, and as far north as South Auckland district in the North Island, being found on Mount Ruapehu but not on Mount Egmont.

Ovum and Egg-laying

Ova laid singly and well attached, persisting more or less undamaged long after lava has vacated mine. Egg occupies an almost invariable position on upper surface of leaf, close to or alongside midrib, rarely more than ⅛ in. from junction of stem and leaf. Fresh ova have not yet been seen, and the following description is taken from empty shells: Class flat (?); shape

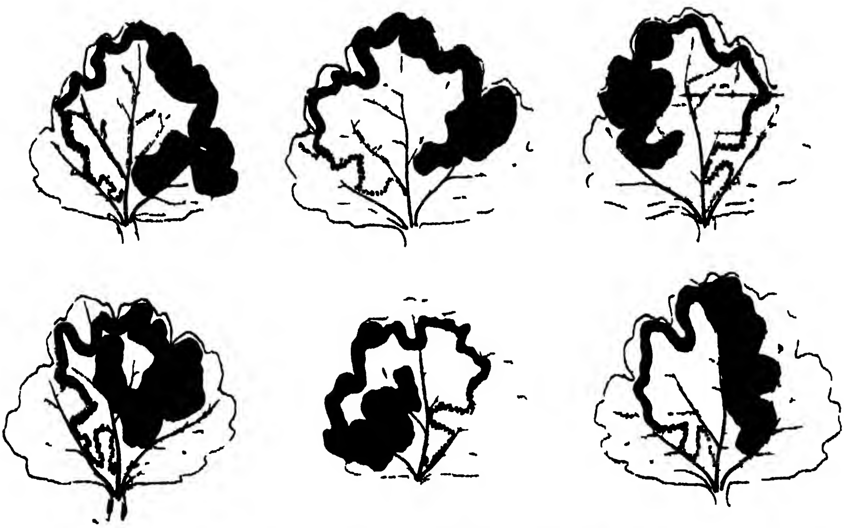


FIG. 1. — Typical mines of *N. lucida* in leaves of *Nothofagus Menziesii.* The white line in the expanded terminal portion indicates the course taken by the larva in formation of the blotch. (Camera-lucida sketches.)

oval, well rounded above, wafer-like, a slight fringe round outer margin of base; no decided sculpturing beyond a slight roughening of shell; shell strong, transparent, shiny, white, becoming more or less filled with frass-granules as soon as larva commences mining; average dimensions, 0·36 mm. by 0·26 mm.

The Mine. (Fig. 1.)

A small narrow more or less tortuous gallery. In its first part it is carried close against lower cuticle, reaching upper only here and there within leaf-cells, this part of mine therefore appearing on upper surface of leaf as a line of minute irregular pale-coloured spots, very much the same as in the case of *N. fulva.* Remainder of mine close against upper cuticle, and entire course of gallery is plainly discernible on both surfaces of leaf. Colour dark grey to brown, but not conspicuous, chiefly owing to small size. From

egg-attachment larva mines directly into leaf and courses outwards towards circumference in more or less indirect manner in region between two of the coarser veins; having reached outer margin, mine follows approximately the serrated edge of leaf towards tip of midrib, and, crossing this, continues along margin for some distance, finally turning inwards towards centre of leaf; about this time larva is full-grown, and emerges from mine by cutting small slit in roof of gallery near termination. Latter third of mine generally somewhat vermiform, and may be so coiled upon itself as to form small blotch.

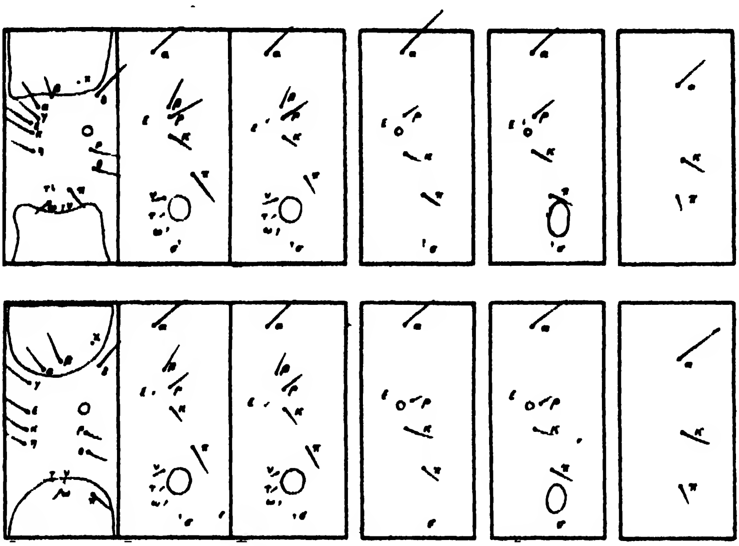


FIG. 2.—Setal map of adult larva of *N. lucida*, *N. ogygia*, *N. erechtitus*, and *N. perissopa*.
FIG. 3.—Setal map of adult larva of *N. fulva*.

Three distinct parts of the mine can be distinguished; at or near the junction of these parts the two moults take place, the third (final) moult occurring within cocoon, the cast skin remaining round caudal extremity. In almost every case the expanded portion of mine is in that half of leaf opposite the one on which egg is laid. There is no tendency to the formation of branches. Frass finely granular, brown, and tightly packed in gallery, completely blocking it except for terminal 3 mm.; occasionally in expanded mine frass will leave a narrow clear area along either side. Colour of mine depends upon age, but as a rule the earlier part is dark grey to black and expanded portion brown. Rarely more than one mine to a leaf. Average length of gallery about 25 mm. Character of mine can most readily be studied by transmitted light.

The Larva. (Text-figs. 2, 4, 11, and Plate 67, fig. 1.)

Length when full-grown, 3·5–4 mm. Ground-colour pale greyish-green, with the greenish-brown alimentary canal showing clearly through transparent dorsal wall. Dorsum of tenth abdominal segment with strong black chitinous rod on either side (fig. 11) and a third in mid-line. Body

cylindrical, slightly attenuated caudad, segments well rounded but not deeply incised; prolegs on II, III, 2, 3, 4, 5, 6, 7, without hooklets. Head flattened, retractile, black. Prothoracic shield black. Cephalic ganglia reddish-brown; ventral chain of ganglia very distinct, reddish-brown, the ganglia connected by double cords. Mines dorsum uppermost. Skin thickly covered with a coarse pile. (Plate 67, fig. 1.)

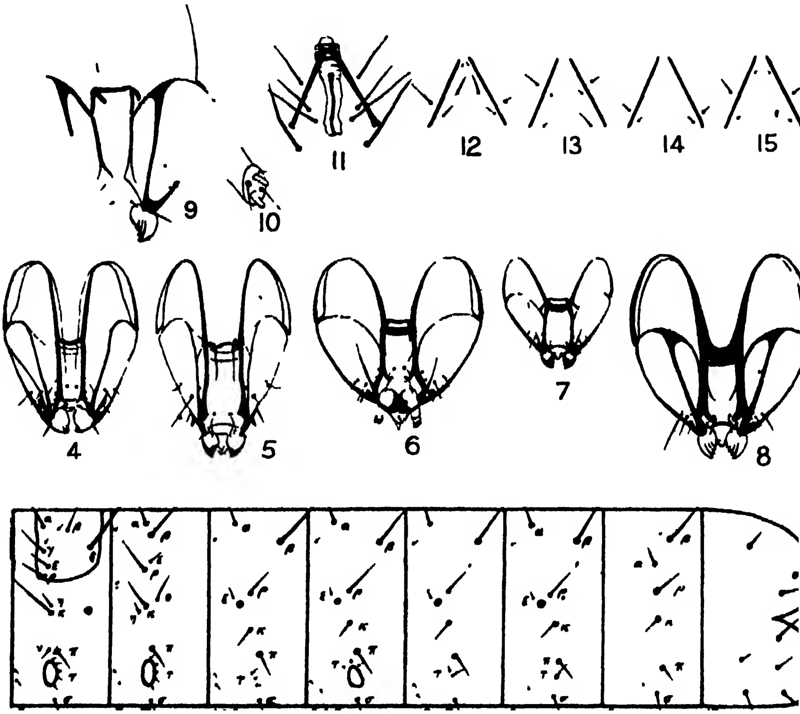


FIG. 4.—Adult larval head-piece of *N. lucida.*
FIG. 5.—Adult larval head-piece of *N. fulva.*
FIG. 6.—Adult larval head-piece of *N. ogygia.*
FIG. 7.—Adult larval head-piece of *N. erechtitus.*
FIG. 8.—Adult larval head-piece of *N. perissopa.*
FIG. 9.—Ventral view of a cleared Nepticulid larval head-piece, showing the nature of the internal skeleton.
FIG. 10.—Antenna of a Nepticulid larva.
FIG. 11.—Setal plan of tenth abdominal segment of *N. lucida.*
FIG. 12.—Setal plan of tenth abdominal segment of *N. fulva.*
FIG. 13.—Setal plan of tenth abdominal segment of *N. ogygia.*
FIG. 14.—Setal plan of tenth abdominal segment of *N. erechtitus.*
FIG. 15.—Setal plan of tenth abdominal segment of *N. perissopa.*
FIG. 16.—Setal map of adult larva of *G. selenitis.*

The larval chaetotaxy of the five species so far dealt with may here be compared. Only larvae in their third (final) instar have been examined, since the setae in the earlier instars are so fine and transparent as to make their charting extremely difficult. The setal plan of adult Nepticulid larva is shown in the figures. The plans of *N. lucida*, *N. perissopa*, *N. ogygia*, and *N. erechtitus* (excluding the tenth abdominal segment) were

found to be identical, whereas that of *N. fulva* differed in pi of the prothorax being placed far caudad of the tau group, and rho in the abdominal segments taking up a position behind and below epsilon, behind and level with the top of the spiracle. In all species beta is absent in the abdominal segments, and an extra minute seta appears above epsilon in the metathorax. In searching for good specific characteristics the chaetotaxy of the tenth abdominal segment was found to offer a slight clue (see figs. 11–15), but the most marked specific characteristics were found in the clothing of the larval skin; these are shown and described in Plate 67. The presence of a minute sensory organ or puncture on the prothoracic shield (marked × in figs. 2 and 3) was found in all specimens.

Camera-lucida sketches of the head-pieces were made, and appear in figs. 4–8, size and shape appear to be the best specific characteristics; all in common have front narrowed caudad, lobes of epicranium extending caudad to a considerable distance behind meeting-point of front and vertical triangle, and the single ocellus on either side.

The Cocoon.

2·5 mm. by 1·5 mm. A small ovoid structure of fine white silk. Unlike the silk of the four species already dealt with, it does not change to brown on exposure to moisture. Cocoon constructed outside mine amidst foliage of food-plant, either in crevices in bark, in angles of branches, or between two leaves. Closely woven and surrounded by a fair amount of loose flossy silk, by which it is attached to its support. At anterior end is a prepared transverse slit, which is kept closed by the loose silk. Construction occupies about three days.

The Pupa. (Fig. 23.)

Female. Ventral aspect: Body roughly oval in outline, flattened dorsoventrally, about twice as long as broad, front bluntly rounded. Maxillary palp stretching from antenna to labrum; labial palpi short, slightly divergent caudad and slightly longer than maxillae. First legs stout, reaching to caudal extremities of second coxae; only a very slight slip of first femur to be seen between leg and maxilla; second legs extend to about half-way between caudal extremities of first and third; a short length of tibae of 3 extends caudad from beneath extremity of 2, while tibia of 2 extends slightly caudad of extremity of 1; third legs appear from beneath caudal extremities of antennae and second legs, and, meeting in mid-line, extend as far as segment 10, farther in the male. Antennae segmented, extend to just beyond second legs, but in male nearly to caudal extremities of third legs. Coxae of about equal length, first about twice as long as broad; they entirely cover ventral abdominal wall beneath. Forewings extend caudad beyond third legs; no sign of hindwings on ventral aspect.

Dorsal aspect: Prothorax extremely narrow, almost obliterated in middorsal line; spiracles on prominent elevations on segments 1–8. Indications of slight mid-dorsal ridge on abdominal segments. Segments 3–7 inclusive in female, and 3–8 inclusive in male, bear anteriorly a single row of about seven small spines directed caudad. A pair of small upturned hooks on segment 9 in female and segment 10 in male. Movement can take place between all abdominal segments excepting last three. Colour at first pale green, a black V-shaped area directed cephalad on dorsum of segment 6.

AVERAGE MEASUREMENTS OF PUPA.

Measurement at	Length from Extreme Front.	Transverse Diameter.	Ventro-dorsal Diameter.
	Mm.	Mm.	Mm.
Upper border of maxillary palpi	0·25	0·62	0·60
Bottom of labial palpi	0·52	0·70	0·60
Bottom of first legs	1·00	0·76	0·62
Bottom of second legs	1·50	0·70	0·70
Bottom of third legs	2·00	0·28	0·35
Extreme length	2·06	..	..

Dehiscence.

Pupa is normally extruded from cocoon to about level of second legs; vertical and transverse splitting occurs as in other Nepticulids already dealt with. In many cases, where the imagines were reared from larvae, dehiscence took place entirely within cocoon.

COMPARATIVE TABLE OF MAIN CHARACTERISTICS.

	The Larva.			The Mine.		The Cocoon.		The Pupa.
	Food-plant.	Skin.	Ventral Chain of Ganglia.	Class.	Average Size.	Position.	Colour	Dorsal Abdominal Spines.
N. fulva .	*Olearia*	Pile excessively minute	Not noticeable	Blotch ..	2–3 sq. cm	Outside mine	Brown	Single row.
N. ogygia .	*Olearia*	Pile minute, sparse	Very distinct	Gallery ..	4 6 cm.	Outside mine	Brown	Single row.
N. erechtitus	*Erechtites*	Pile minute, plentiful	Not noticeable	Gallery ..	3–4 in.	Outside mine	Brown	More than one row.
N. lucida ..	Beech ..	Pile very coarse	Very distinct	Gallery .	25 mm.	Outside mine	White	Single row.
N. perissopa	Rangiora	Minute chitinous plates	Not noticeable	Gallery + blotch	Gallery 4–6 in. Blotch ½ sq. in.	Within mine	White	More than one row.

(28.) Gracilaria selenitis Meyr. (The Beech-gracilaria).

Gracilaria selenitis Meyr., *Trans. N.Z. Inst.*, vol. 41, p. 15, 1909; vol. 47, p. 228, 1915; *Genera Insectorum*, vol. 20, fasc. 128, p. 28, 1912.

The Imago.

Meyrick's Original Description.—See *Trans. N.Z. Inst.*, vol. 41, p. 15, 1909.

Wing-venation is as shown in fig. 24. Note cross-vein below retinaculum (either M_5 or basal portion of M_{1-4} fusing with Cu_1), and Cu_{1b} arising close to base of cell; both these preculiarities were present in the five specimens examined. Male slightly smaller than female, and lighter-coloured, more reddish. There appears to be little or no range of variation.

Type in Mr. Meyrick's collection.

Distribution.

Apparently to be found in any of the silver southern-beech forests. Has been taken plentifully in bush on banks of Waitati Stream, Dunedin; imagos being caught September to December. Mr. Clark has taken it also at Tuatapere, The Hump (Southland), and at Longwood, in December.

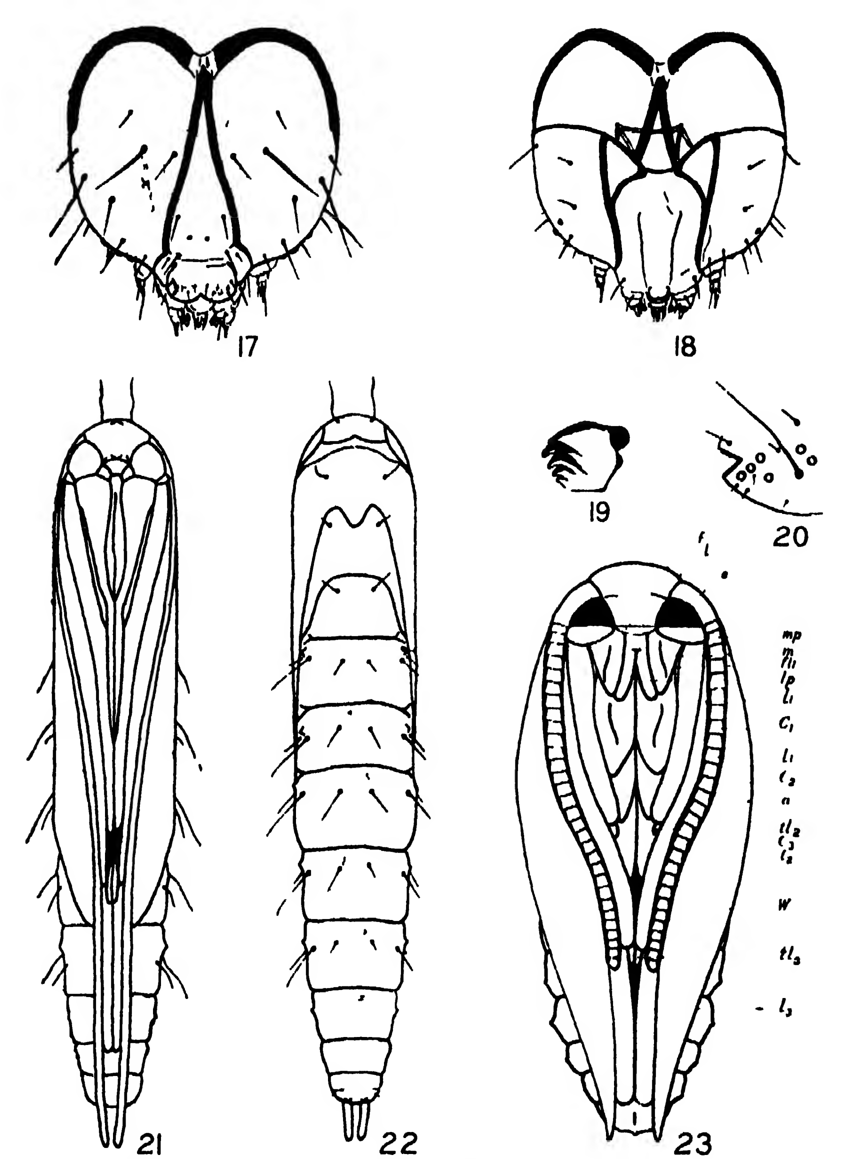


FIG. 17.—Head-capsule of adult larva of *G. selenitis*. Camera-lucida sketch from a cleared specimen. The dotted lines indicate the internal skeleton. View from above

FIG. 18.—Ventral view of head-capsule.

FIG. 19.—Mandible of adult larva of *G. selenitis*.

FIG. 20.—The arrangement of the eyes in adult larva, *G. selenitis*.

FIG. 21.—Pupa of *G. selenitis*, ventral aspect.

FIG. 22.—Pupa of *G. selenitis*, dorsal aspect.

FIG. 23.—Pupa of *N. lucida*, ventral aspect: *f*, front; *l*, labrum; *e*, eye; *mp*, maxillary palp, *m*, maxilla; *fl_1*, femur of first leg; *lp*, labial palp; l_1, first leg; *c*, first coxa; c_2, second coxa; *a*, antenna; tl_2, tibia of second leg; c_3, third coxa; l_2, second leg; *w*, forewing; tl_3, tibia third leg; l_3, third leg.

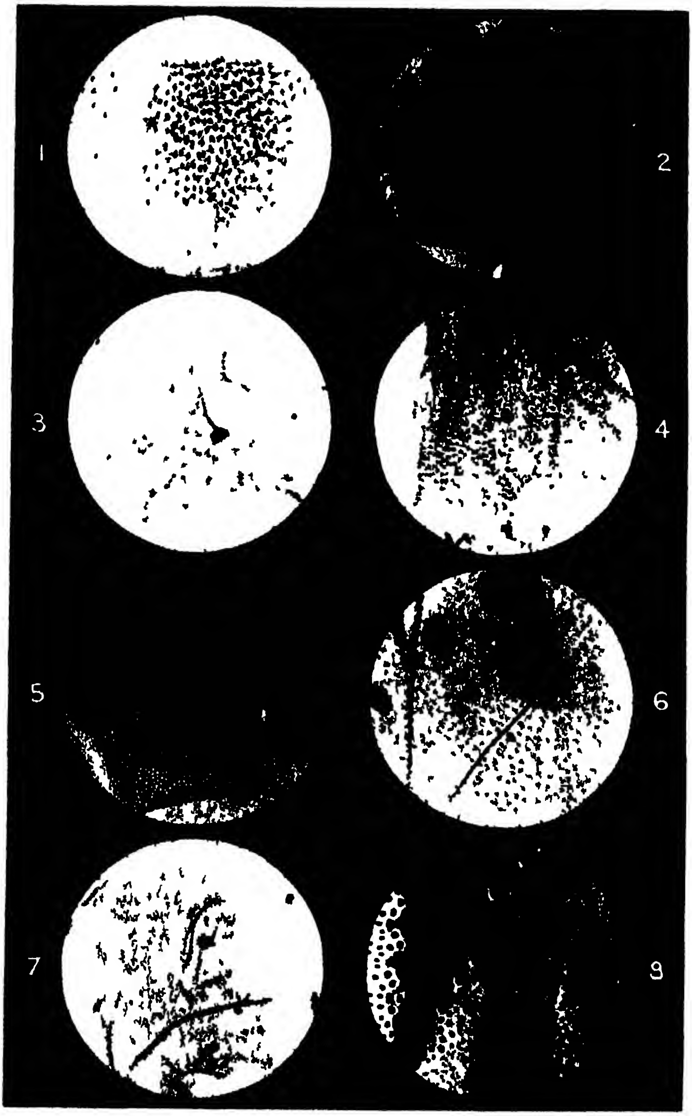


Fig 1 —Skin of adult larva, A *lucida*, 290, unstained Note character of pile and compare length with that of seta shown

Fig 2 —Skin of adult larva, A *fulva* 290, eosine Note minuteness of body pile

Fig 3 —Skin of adult larva, A *oxygona* 290, al carmine Note comparative sparseness of pile

Fig 4 —Skin of adult larva A *erechtitus* 290 al carmine

Fig 5 —Skin of adult larva, A *perissopa* 290, eosine Note entire absence of pile, its place being taken by minute plates or thickenings of skin

Fig 6 —Skin of adult larva, *P polypodii*, 290, unstained Note absence of pile around root of seta

Fig 7.—Skin of adult larva, *G selenitis*, 290, al carmine Note pile consisting of minute triangular points

Fig 8 —Skin of adult larva, *A melanombra*, 290, al carmine Note absence of pile, but thickened platelets of chitin, portion of denser dorsal saddle shown.

Face p 680]

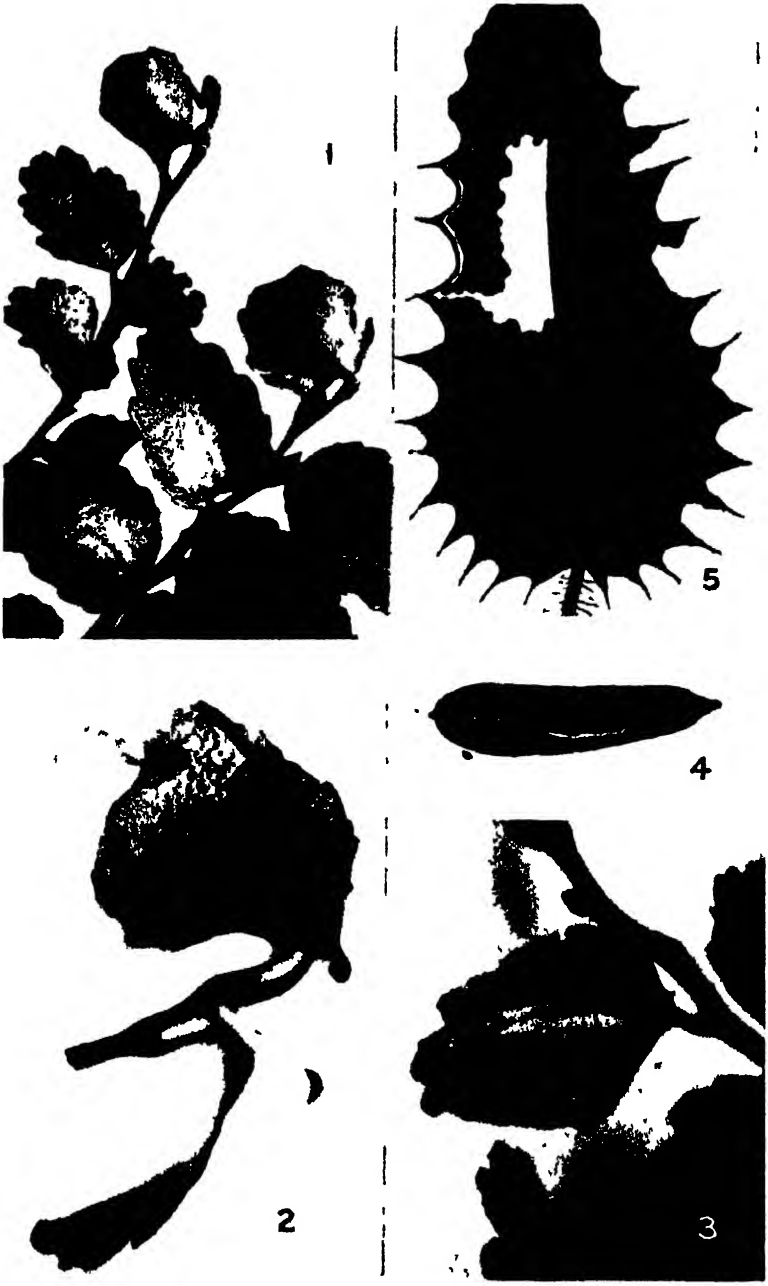


FIG. 1.—Terminal leaves of *N. Menziesii* bound together by larvae of *G. selenitis*; very slightly enlarged.
FIG. 2.—The same, showing dehiscence; × about 4.
FIG. 3.—The same; one of the leaves having been removed to show cocoon of *G. selenitis* and contained pupa. Note frass collected to one side of cocoon. × about 4.
FIG. 4.—Mine of *H. chenopodii* in leaf of common chickweed. Tracing, natural size.
FIG. 5.—Mine of *A. urticae* in leaf of nettle. Tracing, natural size.

Mr. Hudson records it from Mount Holdsworth, Tararua Range, 3,000 ft., 22nd January, 1907 (the first discovery of the species); Mount Earnslaw, 3,000 ft., 15th January, 1914; Mount Arthur, 3,500 ft., 7th January, 1919, and 18th January, 1920. Mr. Philpott has found it plentiful in all the Otago *Nothofagus* forests he has collected in, from 2,500 ft. to 3,000 ft., in December and January, mentioning particularly The Hump, Billow Mountains, Hunter Mountains, Wakatipu generally, Takitimu Mountain, Manapouri region; very sparingly on the Dun Mountain, Nelson. Imagines best caught by beating in vicinity of food-plant, but may quite easily be reared from cocoons. Cocoons were collected on 20th August, 1921, and imagines emerged from 9th to 30th September, the greatest number emerging on 18th.

Food-plant.

The silver southern-beech, *Nothofagus Menziesii* (tawhi, tawai).

Egg-laying.

Nothing at present known.

The Mine.

Characteristics not yet definitely known, but amongst leaves on branchlets holding cocoons were many containing empty narrow galleries on underside of leaves; there is no sign whatever of these galleries on upper surface; mines shallow, and dry cuticle over them had a silvery appearance; it would appear that larva mines more than one leaf. In other

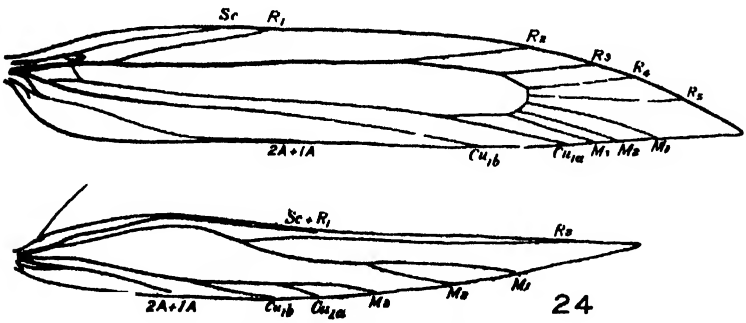


FIG. 24.—Wing venation of *G. selenitis*.

leaves part or all of leaf-substance had been removed, leaving only the two dried cuticles much wrinkled, the under one contracted so as to cause leaf to curl, and in it was the hole by which larva left; hollow within leaf contained a small amount of fine black granular frass. It would seem safe to assume that the larva does not confine itself to one leaf, that the mine is at first a narrow gallery on underside of leaf, and finally the larva blotches entire leaf and possibly more than one. Mines should be looked for during August and November.

The Larva. (Text-figs. 16–20, and Plate 67, fig. 7.)

Full-grown larva, prior to pupating, about 1 cm. in length; pale cream to white, with a narrow pale-green dorsal streak; head pale grey, sutures darker brown, tubercles and setae colourless.

Head with setae shown in figures, which were taken from a specimen cleared in potash and mounted without pressure. Mandible and eyes are shown in figs. 19 and 20.

Larva cylindrical. segmental incisions shallow; thoracic legs well developed; ventral prolegs on segments 3, 4, 5, these and anal prolegs possessing crochets arranged in a lateral penellipse enclosing a transverse series, all uniordinal. Skin thickly covered with microscopic triangular points, except in tubercular areas, which are bare save for setae.

Alpha is a smaller seta than beta, and is situated above and in front of the latter in all segments excepting 9, where it is below; on mesothorax and metathorax and segment 9 it occupies a common tubercular area with beta, rho also being included in this area in the latter segment; rho is placed below epsilon on the thoracic segments, epsilon being absent in 9; eta is directly above kappa in prothorax, but below and in front in remaining thoracic segments, where kappa is closely associated with theta caudad; pi is normal; tau is a varying group as shown; sigma is normal. Several minute subsidiary setae appear as shown in fig. 16.

The Cocoon. (Plate 68, figs. 1–3.)

Two (occasionally three) leaves are cemented together with silk around their outer margins, two opposing leaves, one on either side of branchlet, being chosen; their bases close to stems are first connected and gradually drawn together with silk, then the opposing margins. Should the leaves be more than usually difficult to draw together, the stem of one will be partly cut. In most cases leaves at ends of branchlets were chosen (see Plate 68, fig. 1). A fine thin cylindrical cocoon is constructed, slung like a hammock across the interior between the leaves, usually in the direction of the long axis (Plate 68, fig 3). The silk is exceedingly fine and strong; is at first white but becomes later pale brown. Length, 6-7 mm.; diameter, 1·5–2 mm. Anterior end attached to surface of one of the leaves near, but never at, the attached margin; here, just prior to pupating, larva prepares a small circular exit, the leaf being eaten away till only the thin transparent outer cuticle remains. Besides the cocoon the space between the leaves contains a variable amount of dry frass-granules, mostly collected to one side of cocoon and more or less adherent to it. Cast larval skin remains within cocoon.

The Pupa. (Figs. 21, 22.)

Cylindrical, extremities bluntly rounded; abdomen slightly attenuated caudad from fifth segment; free movement in male between 4–5, 5–6, 6–7, in female between 4–5, 5–6.

Ventral aspect: Head– cutting-plate small and non-serrate; eye only slightly overlapped by antenna; a small area representing maxillary palp separates lower margin of eye from cephalic extremities of first and second legs; a small seta on either side of clypeus near caudo-lateral angle; mandibular area well defined; labial palpi narrow; maxillae broad above, meeting in mid-line below labial palpi, they pass beneath the first legs and reappear lower beyond caudal extremities of these latter, terminating just beyond second legs; femora of first legs encroach upon lateral margins of upper third of maxillae; first legs extending from maxillary palpi above to about level of junction between fourth and fifth abdominal segments, meeting in mid-line in their lower fourth they here overlap maxillae; second legs occupy interval between antennae and first legs, extending from maxillary palpi above as far as or slightly farther than caudal extremities of maxillae; third legs occupy mid-line from caudal extremities of maxillae and second legs to junction of seventh and eighth abdominal

segments, occasionally as long as or slightly longer than body; antennae narrow, segmented, extending beyond abdomen; forewings occupy only about one-fourth of ventral aspect of pupa, and extend to junction of fifth and sixth segments.

Dorsal aspect: Front possesses two well-developed setae, one on either side of and behind prominence of cutting-plate; prothorax widest against antennae, narrow across dorsum but slightly produced cephalad in mid-line; mesothorax possesses a pair of small lateral setae in upper part; metathorax of about same length as upper abdominal segments, hindwings extending only as far as second abdominal segment, a pair of small setae cephalad; indications of a slight median ridge on thoracic segments. Abdominal segments—spiracles small, circular, slightly elevated, those on first segment covered by wings, absent in 9 and 10, those on 8 smaller and situated more ventrad than the rest: a pair of dorsal setae on every segment excepting last four, a long slender dorso-lateral seta on each segment below and behind spiracle, and a smaller lateral one below and in front of the spiracle in segments 2-6 inclusive; on upper part of dorsum of segments 2-8 inclusive is a narrow belt of two or three irregular series of short stout bristles directed caudad, and over remainder of dorsum of these segments, excepting 8, are irregularly scattered a number of very minute spines, most marked in 2 and least developed in 7; segment 10 bears two pairs of very minute tubercles—one pair ventro-lateral, the other dorsal.

AVERAGE MEASUREMENTS OF PUPA.

Measurement at	Length from Extreme Front.	Transverse Diameter.	Ventro-dorsal Diameter.
	Mm.	Mm.	Mm.
Bottom of eyes	0·47	0·76	0·70
Bottom of labial palpi	1·27	0·93	0·93
Bottom of first legs	2·96	0·90	0·93
Bottom of maxillae	3·44	0·86	0·93
Bottom of second legs	3·55	0·80	0·93
Bottom of forewings	3·86	0·73	0·86
Bottom of third legs	4·69	0·42	0·42
Bottom of antennae	5·58	..	..
Bottom of tenth segment	4·86	..	..

Dehiscence. (Plate 68, fig. 2.)

Pupa extruded as far as seventh or eighth abdominal segment. Vertical splitting takes place dorsally along mid-line of vertex, prothorax, and mesothorax, but not extending into metathorax. The front, with antennae, portion of eyecaps, mandibles, maxillae, and labial palpi, becomes almost totally removed, being retained only by caudal extremities of maxillae. Thoracic appendages become more or less freed, but retain their connection caudad.

(29.) Haplomyza chenopodii n. sp. (The Beet-fly).

The Imago.

Female. Frons, antennae, proboscis, palpi, and genae lemon-yellow; ocelli yellow; ocellar triangle black; eyes and occiput black; arista black, pubescent; each orbit with three strong bristles; post-vertical bristles longer than ocellar.

Thorax jet-black, shiny on dorsum; pleurae almost entirely lemon-yellow; two or three small blackish areas ventrad, a larger black area between anterior coxae; scutellum broadly lemon-yellow with a narrow brighter medial stripe; four pairs of dorso-central bristles, anterior two pairs very weak; two series of about four setulae each between the two anterior pairs of dorso-centrals; apical scutellar bristles arise from yellow area, while lateral scutellar bristles are outside yellow area.

Abdomen—dorsum black, posterior margins of tergites obscurely yellowish; sides yellow; under-surface dark-greyish.

Legs—coxae, and femora yellow with a slight obscure blackening externally; tibiae and tarsi dark-grey.

Wings greyish, veins black; costa to end of fourth vein at tip of wing; hind cross-vein absent; halteres lemon-yellow

Length, 1·3 mm.; length of wing, 1·6 mm.

Type in author's collection; reared from mines in silver-beet. Wanganui.

Distribution.

Recorded from Wanganui, Auckland, and Napier (L. A Hay), Governor's Bay, Christchurch (Tapley), and is probably widely distributed throughout New Zealand. Appears to be most plentiful about December.

Food-plants.

Has been reared from white and silver beet, spinach, mouse-ear chickweed (*Cerastium vulgatum*), common chickweek (*Stellaria media*). and fat-hen (*Chenopodium album*).

Egg-laying and Larva.

Eggs laid singly in minute semicircular pockets forced under upper cuticle of leaf. Average diameter of egg-pocket, 0·7 mm.

Full-grown larva cylindrical, intestinal tract filled with dark-green food and very conspicuous through the transparent skin. Colour whitish anteriorly, greenish posteriorly, extreme posterior end yellow. Posterior respiratory processes long and prominent. Average length of full-grown larva, about 1·7 mm. Each half of mandibular sclerite with two very prominent teeth. First moult occurs about 8 mm. along mine from egg-pocket; length of cast pharyngeal skeleton, 0·1 mm. Second moult about 18 mm. from pocket; cast pharyngeal skeleton, 0·15 mm. in length.

The Mine. (Plate 68, fig. 4.)

A simple gallery, more or less narrow, tortuous, and gradually expanding. Greatest final width averages 1 mm.; average length, 40-60 mm.; width at commencement, 0·14 mm. Best seen on upper surface of leaves, but may be in part or wholly on under-surface. Colour pale green when fresh, rapidly becoming white; there is no discoloration of leaf other than this. Sometimes short blind branches may be found; margins of gallery are somewhat uneven under a lens. In small leaves, or when several larvae are mining in the vicinity of one another, mines may cross and recross and become much involved, but there is never blotch-formation. Mines found mostly in leaves nearest the ground. Frass is black, scanty, semi-viscid, in a thin irregular line broken into short lengths, first on one side of gallery and then on the other. The larva escapes from terminal part

of mine before pupating. In trying to rear these flies I have noticed numbers of immature larvae leave their mines; these have not again entered a leaf, but have crawled about the jar for some hours and then died without pupating. Numbers of immature mines are also to be found in plants growing naturally; I think such larvae have been the victims of parasites and that larvae do not otherwise leave the mine before maturity. Average duration of larval existence, fourteen days.

The Pupa.

Pupation occurs outside mine and generally on ground beneath food-plant. Healthy pupa brown; segments moderately rounded, of about equal length; surface very slightly roughened with minute transverse rugae; intersegmental areas bearing several series of very minute spines; anterior respiratory processes small, slightly expanded at tips, black-tipped, only half as far apart as posterior, which are comparatively thick with black expanded tips. Average length of pupa, 1·33 mm.; greatest transverse diameter, 0·62 mm.; greatest ventro-dorsal diameter, 0·58 mm. Average duration of pupal period, twelve days.

When pupating, larvae shun light as much as possible, seeking the darkest corner, but not penetrating beneath the surface of the soil.

(30.) **Agromyza urticae** n. sp. (The Nettle-fly).

The Imago.

Male. Frons orange; ocellar triangle, eyes, and antennae black; arista pubescent. Each orbit with four strong bristles; post-vertical bristles longer than ocellar.

Thorax—dorsum black, sides lemon-yellow with a relatively large rectangular black area below and in front of wing-base, and several smaller irregular patches below base. Halteres lemon-yellow. Scutellum broadly lemon-yellow. Four pairs of dorso-central bristles with three or four series of setulae between anterior three pairs.

Abdominal tergites black, yellowish posteriorly.

Legs black, lower joint of femur yellowish.

Wings pale grey, veins dark grey; costa to fourth vein at tip of wing; penultimate section of fourth vein one-sixth as long as ultimate; and one-fourth as long as ultimate section of fifth. Length of wing, 2·4 mm.

Length, about 2 mm.

Type in author's collection; reared from mines collected by Mr. Tapley at Governor's Bay, Christchurch.

Distribution.

First discovered by Mr. Tapley at Governor's Bay, in December, 1921. I have succeeded in rearing only a single specimen from numerous mines sent me by Mr. Tapley, who also obtained for me a number of the flies caught on the food-plant. The larvae suffer greatly from the attacks of hymenopterous parasites. The fly would appear to be common at Governor's Bay, but has not been recorded elsewhere.

Food-plant.

The common nettle (*Urtica ferox*).

Egg-laying and Larva.

Ova deposited singly in small pockets forced beneath the under-cuticle of leaf. Larva when full-grown 2–2·5 mm. in length, pale lemon-yellow, brighter orange posteriorly, with a black spot on dorsum of terminal three segments. Respiratory processes short and black-tipped.

The Mine. (Plate 68, fig. 5.)

A gallery expanding in its latter half into a somewhat irregular lobed blotch. Though visible on the under-surface of leaf, more conspicuous on upper, lying as it does immediately under this cuticle. Earlier part of the mine usually directed towards outer margin of leaf, which it follows for a longer or shorter distance, whereas blotch portion is usually in middle part of leaf against the midrib, which it does not cross. Average total length of mine, 2–3 in., the blotch occupying about ¼ square inch. Colour of mine pale green. Frass black, granular, scanty and scattered, tending to collect into small heaps, especially in blotch portion. When there are several larvae mining in close proximity their mines usually coalesce, and a large composite blotch results. Larva escapes through a cut in floor of mine and descends to ground to pupate. There is a certain amount of dark discoloration of the leaf on either side of first portion of gallery.

The Pupa.

Pupation takes place outside the mine (occasionally inside when parasited) amongst rubbish on the ground. Length of pupal period, about three weeks. The pupa itself is dark brown in colour, similar in type to that of *A. citreifemorata.*

ADDENDA AND CORRIGENDA.

Nepticula ogygia.

New localities: Catlins (W. G. Howes); Stewart Island (Miss Scott); Mount Ruapehu (Waimarino side), 3.700 ft., common (M. N. W.). The larvae inhabiting the very young leaves of *O. arborescens* (= *nitida*) are uniform pale yellow when full-grown.

Nepticula fulva.

New localities: Nelson (A. Philpott); Governor's Bay, Christchurch (J. F. Tapley); Mount Ruapehu, north side, 3,700 ft. (M. N. W.).

Nepticula progonopis Meyr. (*Trans. N.Z. Inst.*, vol. 53, p. 336, 1921).

Add this to the list in beginning of Part II of this series.

Nepticula tricentra (*Trans. N.Z. Inst.*, vol. 53, p. 212).

Mr. Meyrick, who has seen bred specimens of this moth, says it is not *tricentra*, but a new species. I describe it below as *N. erechtitus*; its life-history is as given under the name *tricentra* (No. 11) in Part II.

Nepticula erechtitus n. sp.

♀. 5 mm. Head and palpi pale brownish-white. Antennae, thorax, and abdomen grey. Legs dark grey. Forewings, ground-colour pale brownish-white, irrorated with dark-grey to black scales more or less

condensed into three rather diffuse transverse bars across wing—one at base, one at ½ which is somewhat constricted in middle, the third occupying terminal one-fourth of wing; the dark scales are more closely packed in middle of each bar: cilia light grey, a black cilial line. Hindwings and cilia light grey.

Food-plant: Erechtites arguta (not *Senecio bellidioides*, as previously stated). Also found mining in *E. prenanthoides* in the same localities.

Three further species of *Nepticula* are under observation—one mining in the lacebark (*Hoheria populnea*), one in the yellow kowhai (*Sophora tetraptera*), and one in a small-leafed ground-plant on Mount Egmont.

Phytomyza albiceps (*Trans. N.Z. Inst.*, vol. 54, 1923, p. 485).

The following note is from Dr. Martin Hering, of Berlin: "The fly, mining in the sow-thistle, which you call *P. albiceps* Mg. does not belong to this species, but is *P. atricornis* Mg. This insect is mining in Europe also in the sow-thistle (*Sonchus*), and in a great number of other plants. It is the most polyphagous leaf-miner in the world. I have compared your specimen with ours, and there is no difference. *P. albiceps* Mg., the *Artenisia* leaf-miner *never pupates in the mine.*"

On the Identity of Eurytoma oleariae *Maskell.*

By A. B. GAHAN, of the U.S. Department of Agriculture, Bureau of Entomology.

Communicated by David Miller.

[*Read before the Wellington Philosophical Society, 29th October, 1923; received by Editor, 5th November, 1923; issued separately, 28th August, 1924.*]

IN January, 1922, the Bureau of Entomology of the United States Department of Agriculture received from E. S. Gourlay, of the Biological Department, Canterbury College, Christchurch, New Zealand, fifteen specimens of a small hymenopteron which he had determined as *Eurytoma oleariae* Maskell. According to the correspondent, these specimens were reared from galls on *Olearia furfuracea*, which were also inhabited by a species of Cecidomyid. Samples of the galls were also received. Comparison of the specimens and the galls with Maskell's description and figures (*Trans. N.Z. Inst.*, vol. 21, 1888, p. 255, pl. xi, figs. 1–16) left no doubt that the species had been correctly identified.

This species is not an *Eurytoma*, however, nor even a Chalcidoid, but belongs to the Serphoidea and to the family Platygasteridae, where it agrees best with the genus *Metaclisis* Foerster of the tribe Inostemini. *Metaclisis* is said to have the scutellum flat and the antennal club of the female three-jointed. In the present species the scutellum is not wholly flat, but transversely pillow-shaped as in many species of the genus *Platygaster*, while the antennal club is not very well defined but appears to be six-jointed. One might with justice, perhaps, propose a new genus for it, but the relation to *Metaclisis* is apparently close, and it is deemed best to place it in that genus for the present.

Maskell's description is obviously inaccurate in some respects. The following descriptive notes will aid in recognition of the species.

♀. Length, 2·3 mm. Head transverse, narrower than thorax; vertex entirely and temples above granularly sculptured and pilose; frons smooth and glabrous (sometimes with a narrow orbital line faintly granular) with a very small but distinct median tubercule in front of median ocellus; face, cheeks, and temples below smooth and sparsely hairy; occiput distinctly margined; viewed from front the head is subtriangular and broader than high; antennae ten-jointed, weakly clavate; scape moderately long and somewhat curved; pedicel fully twice as long as thick; third joint as long and about as thick as pedicel; fourth approximately two-thirds as long as third and about as thick; fifth not quite as long as fourth and slightly thicker, about as broad as long; sixth to ninth subequal and subquadrate or very slightly longer than thick; tenth conical and very slightly longer than preceding joint. Thorax ovoid, broadest before tegulae; pronotum rounded in front and deeply and broadly emarginate behind; parapsidal grooves complete and sharply impressed; scutellum slightly convex and about twice as broad as long; axillae transverse, deeply depressed or sunken and meeting on median line; pronotum, mesoscutum, and scutellum finely granular and closely pilose; propodeum with a shallow median channel bounded on each side by prominent carina, transversely rugose between carinae and very faintly granular and pilose laterally; mesopleura glabrous and polished with three of four distinct longitudinal striae near dorsal margin; metapleura pilose but practically smooth; legs moderately long and slender, posterior tibiae with two unequal spurs; forewings with a complete basal cell, the submarginal, basal, and median veins distinct though more or less vestigial, the submarginal faintly traceable for nearly half length of wing and terminating in a nearly obsolete knob; whole surface of wing ciliated, basal portion a little more sparsely so than remainder; hindwing with a non-ciliated area extending obliquely basad from hooklets to posterior margin. Abdomen as long as head and thorax or a little longer, as broad as thorax, broadest at apex of second tergite, and distinctly margined laterally; first tergite broader at apex than long down middle and strongly longitudinally striated; second tergite a little more than twice as long as first, much broader at apex than at base, with a large ovate and well-defined depressed area on each side of middle at base, surface of tergite mostly smooth and glabrous but with several elongate punctures or short striations at basal middle, the depressed areas very finely punctured and pilose within, and lateral margins of tergite sparsely hairy; tergites beyond second, short, weakly punctate, and hairy; ovipositor concealed.

Black; antennae black; coxae concolorous with thorax; legs, except coxae, reddish-testaceous; marginal carina of abdomen reddish beneath; forewings faintly fuscous, the infuscation not uniform but more intense on median portion of wing; hindwing also faintly fuscous with hyaline spot behind hooklets.

♂. Similar in every way to female except in antennae. These are not at all clavate, third and fourth joints are subequal and each a little longer than pedicel, fifth a little longer than thick, sixth to ninth subequal and distinctly longer than thick, tenth ovate and about one and a half times as long as ninth; all flagellar joints cylindrical and very shortly petiolate but not serrate.

Described from fifteen specimens received, as already stated, from E. S. Gourlay. The species is without much doubt parasitic upon a Cecidomyid, possibly *Cecidomyia oleariae* Maskell. It seems highly probable that more than one species of Cecidomyidae has been confused under this name by Maskell.

Maori Music.

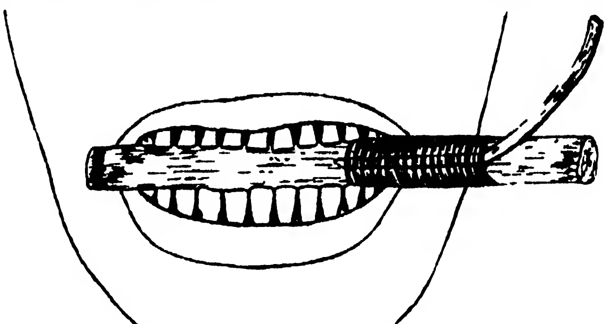
By JOHANNES C. ANDERSEN, F.N.Z.Inst.

[*Read before the Wellington Philosophical Society, 27th June, 1923; received by Editor, 31st December, 1923; issued separately, 28th August, 1824.*]

Plates 69, 70.

SINCE publication of the paper in volume 54 more details have come to hand regarding certain of the musical instruments of the Maori.

The accompanying illustration of the *roria*, or Maori jew's-harp (fig. 1), is from a sketch sent by Mr. George Graham, of Auckland. The vibrating-strip, made from supplejack (kareao), was, he says, called *arero* (tongue): it gave like a spring, and stood considerable use. When it showed signs of losing its elasticity, or of cracking, it was replaced by a fresh piece. It gave rise to a pungent proverb: *He arero kareao ka whati, engari te arero wahine kaore kia whati—haere tonu ana* (A supplejack tongue will become cracked; not so the tongue of a female—it goes on for ever). Evidently even Maori gallantry suffered lapses—but truth will prevail. Mr. Graham says he last saw the *roria* in use at Kaipara about 1885.



H. Hamilton, del.

FIG. 1.—A *roria*, or Maori jews'-harp, as held.

The same correspondent says that in old days a crier (*kai-karanga*) called attention to the fact that an announcement was to be made on the *marae*, or village square, by a blast on a *pumoana*, or conch-horn (Plate 69, fig. 1). At the funeral obsequies of an old Ngati-Paoa chief of high rank, Rawiri Puhata, the call was made by means of a glass bottle, first drained of its "hard stuff."

Hamilton (*Maori Art*, p. 391) notes particulars of a "calabash trumpet" mentioned by some authors, a specimen being in the British Museum. He believed it to be "almost peculiar" to the Taranaki coast. It was made from a small carefully-selected calabash (*kahaka*), in the side of which two or three holes were punctured. It gave only a small variety of notes, and is said to have been used to summon people to meetings. Thomas Moser, from whose *Mahoe Leaves* (p. 38) Hamilton derived part of his information, says it was called *rehu*, and he called the sounds it made a "most

horrid noise." The surface of the calabash was ornamented with incised lines, made when the rind was soft. The specimen in the British Museum is about 3½ in. in diameter and 7½ in. in circumference.

Mention should be made of the *pahu*, though this was used only for emitting a great body of sound: as in other parts of the world, it was used for signalling (see Hamilton, *Maori Art*, pp. 98, 384).

The following particulars are from a note by the late Captain Mair. The *pahu*, *pato*, or wooden gong, was a single slab of totara (*Podocarpus*

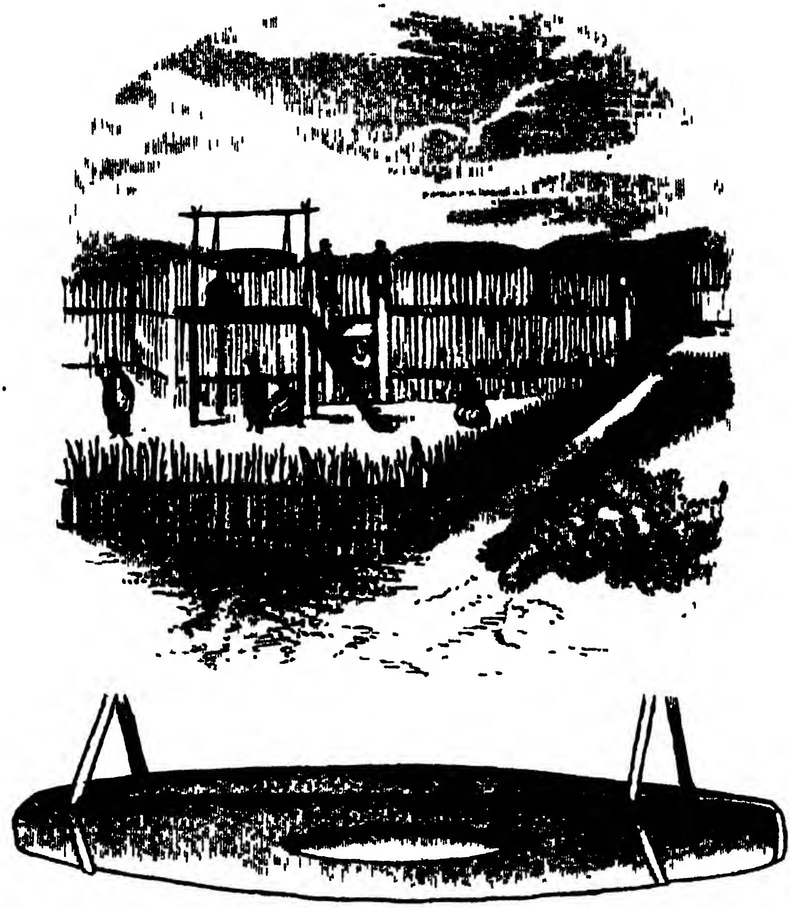


FIG. 2.—A *pahu*, or war-gong. (From White, *Ancient History of the Maori*, vol. 4, p. 128.)

totara) or matai (*Podocarpus spicatus*), sometimes 30 ft. in length, 2 ft. or 3 ft. in breadth, and 6 in. in thickness. It was suspended by two stout ropes from a ridge-pole built on a high *rangi*, or platform, in an angle of the *pa*, the platform being approached by a ladder. In the centre of the slab there was usually an elliptical hole 2 ft. or 3 ft. in length. The slab was struck with a heavy club made from maire (*Olea Cunninghamii*), and under favourable circumstances could be heard to a distance of from six to ten miles. (See fig. 2.)

"During the Maori War," writes Captain Mair, "my Native contingent at early dawn surprised an Urewera village near Maungapohatu. Some of the enemy escaped and gave the alarm by sounding a *pahu* situated on a high hill above the settlement. The signal was immediately answered from a *pa* about nine miles down the Waimana Valley, below Tawhana. The deep thundering notes of the distant *pahu* came booming up the valley, reverberating through the wooded peaks, finally dying away in a thousand echoes among the lofty cliffs."

Sometimes *pahu* were formed out of living trees which happened to be hollow, by cutting a tongue 20 ft. or 30 ft. in length out of the standing trunk. The lower end was struck a few feet from the ground, and a scale of three or four notes obtained by striking the tongue higher or lower.

Again Captain Mair writes: "There are several celebrated specimens of this kind of *pahu*, or *pato*, in the Urewera country, some of which have been in use from time immemorial. One very famous one, called Opato, stood on a high hill overlooking the Whirinaki Valley at Te Whaiti. In 1869, when Colonel Whitmore's expedition marched through the Urewera country, the friendly Native chiefs who accompanied the force pointed out the necessity of obtaining possession of this gong. Accordingly I was sent some miles in advance during the night with ten picked men to seize this spot, and next morning a successful dash was made upon the rebel position at Harema, which was taken with many prisoners and heavy loss to the enemy."

Another instrument of percussion, whose mention follows that of the *pahu* as naturally as the mention of Venus follows that of Mars, is the *pakuru*. This instrument, too, is a perfect evidence of the Maori love of the beautiful. It consists of two strips or rods of wood, respectively 14 in. or 15 in., and 6 in. long. The longer rod is the principal part of the instrument, and is made from matai, mapara (?), or kaiwhiri (= poporo-kaiwhiri, *Hedycarya arborea*). It is nearly 1 in. in diameter, flat on one side, convex on the other: according to Captain Mair's notes, it is ½ in. thick and from 1 in. to 2 in. deep. Sometimes it is beautifully carved, or merely has notches (*whakakaka* pattern) cut along the edges. This rod is held in the left hand, and one end placed between the teeth, flat side down. It is struck with the small rod, made from the same wood, held in the fingers of the right hand. The striking, or tapping, is done in time to the words of the song, and the movements of the lips, as with the jews'-harp, cause different sounds or notes to be emitted by the longer rod. (Hamilton, *Maori Art*, p. 385.)

According to Captain Mair, the end of the longer rod was held lightly by the extended fingers of the left hand, the other end being held near the mouth. While striking the rod so held now and again with the shorter rod, the performer breathed the words of a song or chorus upon the wood, causing the most pleasing vibrations or waves of sound. "I have watched a number of skilled performers, standing in a row," he writes, "their swaying bodies and little tapping mallets keeping the most perfect unisons. Now rising shrill, or dying away in the mournful cadence of some love-song, the effect is remarkably melodious and pleasing."

White (*Ancient History of the Maori*, vol. 2, p. 130) gives yet another slightly differing description of the *pakuru* and the manner in which the rod was held. He says it was made from matai, was about 18 in. long and 1 in. in diameter, slightly flat in the centre, and tapering a little at each end; the ends were carved, the middle left smooth. It was suspended

on the thumb of the left hand by a piece of string tied to each end of it, so that one end should be a little within the teeth when the mouth was partially open. The performer held in his right hand, interlaced between the three middle fingers, another piece of matai, about 10 in. long and as thick as a man's middle finger, and with this he struck the suspended piece gently while he breathed the words of the chant, producing the higher or lower tones by closing or opening his lips. This description was given White by the Ngati-Hau, who also gave the words of the *haka* that was sung to the accompaniment of the *pakuru* by the sisters of Tinirau when looking for Kae, the slayer of the pet whale Tutunui. Mair's description would be from the Arawa; there were probably local variations in make and method. The principle is that of the suspended *pahu* and of the modern xylophone.

Hamilton (*Maori Art*, pl. 55, fig. 1) gives an illustration of a most artistic example of the instrument. In this the end of the long rod held in the fingers is carved with a characteristic head, through which a hole has been pierced to admit a double cord of flax, on which are threaded short pieces of shells of *Dentalium*, a beautifully white cylindrical shell, used in a simile when complimenting a young woman on the whiteness of her teeth. The striking-rod, pierced at its narrower end, is also attached to this cord, which thus serves the double purpose of use and ornament.

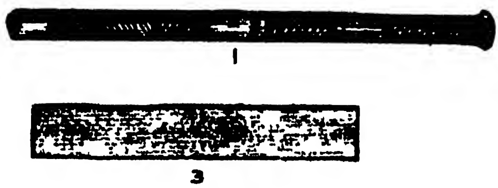


FIG. 3. One form of *pakuru*. 1, The striking-rod; 2, 3, a plain long rod. (From White, illustrations prepared for *Ancient History of the Maori*.)

This rod is about 6 in. long—the principal rod is 14 in.—and is slightly cone-shaped, the base being inlaid with a neatly-cut ring of haliotis-shell. The principal rod is carved on the rounded face, and a diagonal banded pattern slightly burnt on the flat surface—the pattern looking as if it were a spiral encircling the rod. The whole appearance of this *pakuru* is extremely beautiful. Hamilton quotes a pretty *pakuru*-song, obtained from Captain Mair:—

Whakarongo mai taku hine,
Ki te tangi pai o taku pakuru
Taoro haere ana ki Pari-karangaranga,
Hei kawe atu i te aroha,
Rere tomairangi i runga o te rau,
Tiorooro ana ki runga puke,
Hei whakoho i to moe,
E te hoa whakaipo e—i.

Listen now, my lady-love,
To my sweet sounding *pakuru*,
Sending forth its melody,
In echoing cliffs resounding,
Breathing forth my love to you,
As soft as dew on leaves,
Sounding from hill and dale,
Arousing from sweet sleep
She who fills my nightly dreams.

A finely carved example of the *putorino*, recently (1923) acquired by the Auckland Museum, is shown in Plate 70, fig. 4. This instrument was bought from Pora Taki, of Rapaki, Lyttelton, by J. Martin, about the year 1873: Pora Taki said it had belonged to his grandfather. Captain Mair writes that the instrument was sounded by the performer blowing obliquely into the wide upper aperture, raising or lowering the pitch by stopping the aperture at the small end with his forefinger. "It required a vast amount of wind to produce the loud booming or toot-tooting sound." There are specimens without the aperture at the lower end; the sound of these could evidently only be modified by the changing position of the hand over the central aperture.

When last year's paper was written there was no genuine example of a *putorino* available in the Dominion Museum. The instrument tried was known to be of modern trade manufacture, so could not be relied upon, and the cast of the double *putorino* in the Museum (Plate 70, fig. 2) is of no use for experiment. A most perfect specimen has, however, recently been found in the Museum. It is of undoubted genuineness, as it and a double *putorino* (Plate 70, figs. 1 and 3) formerly belonged to the old-established Lord St. Oswald collection, and is believed to have formed part of the collection taken from New Zealand by Captain Cook. This *putorino* measures 52·5 cm. in length, and 5 cm. across the widest part, 25 cm. from the upper end. The aperture at the upper end is oval in shape, 2 cm. across, 1·75 cm. in depth. The lower end tapers to a width of less than 1·5 cm., and is pierced with a hole about 3 mm. in diameter. It is not clear what purpose this hole serves; it possibly helps to purify the quality of the notes emitted. The mouth-opening in the middle of the instrument is 2·75 cm. across, constricted in the centre as in Plate 70, fig. 1, where two views, side view and full view, are shown. The binding is of very finely-split kiekie-root: it is not tied, but the ends are drawn under the binding as in the binding of a cricket-bat. It also seems to have been bound over a cement, of which, too, there are traces at the joined edges of the wood. The protruding tongue of the figure at the top of the *putorino* (see the side view of Plate 70, fig. 1) is caught in a prong springing outwards and upwards from the body of the instrument. On the opposite side (the back), at the lower end, is a smaller carved head. The side view shows the outward-arching figure of the blower at the sound-hole, carved in high relief. The dark-brown wood of the instrument is beautifully smooth and polished, like the wood of an old violin. No attempt has been made to carve the portions between the bindings, as in the Auckland instrument.

A fine clear trumpet-note is produced by blowing bugle-fashion into the upper aperture; and by closing less or more of the central mouth with the forefinger, resting on the side edge, the note, which is F sharp, a fourth below middle C, can be lowered to E very slightly flattened—not so much as quarter flat. This gives a range of slightly over a tone. The range seems much more, and the writer, after evoking a Maori melody from the long-silent instrument, was surprised on taking the pitch to find that the range was so small.

A remark by Hare Hongi on this point is significant. He had been singing a Maori melody for Alfred Hill, who remarked that the whole was within the compass of a tone. "Surely not," said Hare Hongi. "Yes; sing it again." He sang it again. "Yes, it is within a tone." "Do you know," remarked Hare Hongi, "I felt that I had been ranging

over an octave." So it is; these minute subdivisions of a tone do not, after a time, seem minute at all.

The tone of the Auckland instrument is not so clear; its pitch is just on middle C, and it can be raised or lowered slightly by tightening or loosening the lips while blowing. The instrument has a pronounced bend at the neck.

The pitch of the double *putorino* is also F, but slightly flattened. Neither on it nor on the Auckland instrument are the notes produced so freely as on the *putorino* of fig. 1. Once the pitch is struck, this instrument seems to draw the note from the blower, so that it can be played *pp* as easily as *ff*. The other instruments appear to resist the blower. No apparent differences were produced in the tone of the double *putorino* when the two apertures were differently covered. There are smaller *putorino* in the Auckland Museum, and these are higher in pitch than these larger and better instruments. These smaller *putorino*, like the double one, are plain compared with the other two; it may be that greater care was lavished on these two because of their finer speaking qualities.

It is certain now that the *koauau* and *putorino* could be played in unison—one a female voice, one a male.

Fig. 4.—A flute, *porutu*, made of wood.

Captain Mair mentions a kind of flute, *porutu*, generally made from a young straight branch of kaiwhiri, hollowed out by means of fire. Its length was from 1 ft. to 16 in., its diameter ¾ in., and it was elaborately carved, as in fig. 4, from a rough drawing by Mair. The name *porutu* is apparently a Maori form of the word "flute"; and, judging by this and the general appearance of the instrument, it would appear to be a modification of the flute or of the fife.

The long ordinary flute, adapted from the European flute, might on occasion be played with the nose. I learn from Te Rangi Hiroa of a Niue woman whom he saw using a long flute in this way. It was held with the lower end towards the right. Between the right finger and thumb she held a stick the length of a pencil, blocking the right nostril by pressing it with the end of this stick, and blowing with the left nostril. The flute was held with the left hand. The holes were covered by the free fingers of both hands. This would be a kind of trick performance, but it suggests that the nose-playing was not considered seriously. The nose-flute was, however, commonly known through the Pacific.

Captain Mair's notes on the *koauau* are good. He writes that it was the most prized of all the Maori musical instruments. It was often made from the arm-bone or thigh-bone of an enemy slain in battle, was from 5 in. to 6 in. in length, and sometimes finely carved. It was generally carried suspended from the neck by a piece of string, a loop at one end being passed over a toggle at the other end. This toggle, called *uhi*, was a small piece of white albatross-bone. A hole was pierced on one side at the middle, the cord passed into the hollow of the bone and knotted so as to prevent its slipping out again. Mr. Graham, above referred to, says the toggle was called *poro;* and, the albatross being *toroa*, the full name was *poro-toroa* when the bone of that bird was used. Human-bone and moa-

bone were also used. He has seen one specimen of wood, beautifully carved. It was made in the same way that the *putorino* was made, the wood being split, hollowed out, lashed together again, and carved. This unique *poro* perished, like many another Maori treasure, in a house-fire. It should be noted that the bone artifact shown on plate 85, fig. 6, *Trans. N.Z. Inst.*, vol. 54, p. 752, 1923, and recorded as "Bone *koauau* (?) in British Museum," is not a *koauau* at all, but a bone toggle that evidently belongs to the *koauau* of fig. 1. Captain Mair writes that there are several historical *koauau* in the Auckland Museum, the most notable one being named "Te Murirangaranga." It is said to have been made from the arm-bone of a *tohunga* named Te Murirangaranga, who was slain by Whakaue for an affront put upon his son Tutanekai. It was upon this instrument that Tutanekai is said to have played when he lured Hinemoa to swim from the mainland to the island of Mokoia. A *hapu* of Ngatiwhakaue called Ngatitutanekai take special pride in being descended from Tutanekai, and they are skilled in music, as he was said to be. Quoting from the notes, "The writer has often, on a clear summer evening, sat on Pukeroa, a hill above Ohinemutu village, and heard the clear piccolo strains of a *koauau* wafted across from Mokoia Island, a distance close on four miles."

Since the above paragraph was written the writer has visited the Auckland Museum, and has elicited music from the long-silent *koauau* mentioned. It may be the historic flute of Mokoia, or it may not—this honour is claimed for about ten different flutes—but the sounds emitted are most sweet and pleasing; they are mellow and flute-like, not shrill like those of the piccolo. The bone is brownish-yellow with age, the interior partly honeycombed, the edge on which the lip rests ragged and sharp to touch, but the sweetness of the notes remains. The *koauau* is 133 mm. in length; the bore, which is rough and irregular, is 16 mm across the upper end, 12 mm. across the lower. There are three holes pierced in the side, their centres being respectively 23 mm., 45 mm., and 91 mm. from the top. There is a raised ridge on the back, pierced with a hole for suspension, 48 mm. from the top. There is a little incised carving at the two ends, and the pattern, two double rings with cross-cuts and connecting cuts front and back, is the same as that on the wooden mouthpiece of the shell trumpet "Te awa a te atua." The lowest note of this *koauau* is high B, the three following being B a quarter (almost half) sharp, then C a quarter sharp, and D.

There are other noteworthy specimens of the *koauau* in the Auckland Museum. One, named "Ngarangikakapiti," was made from the arm-bone of an Urewera chief of that name who was slain by the Tuhourangi in the fight at Pukekahu about the beginning of the present (? nineteenth) century, and was given to Captain Mair in 1866 by Tuhotoariki, a noted old Tuhourangi wizard, who was entombed for several days under a fallen *whare* during the Tarawera eruption. Another was made from the leg-bone of the notorious Peka te Makarini, the executioner under Te Kooti, who fell in the fight at Waikorowhiti on the 7th February, 1870. An old chief from Mohaka fashioned it, and sent it to Captain Mair. The old man was a connoisseur, saying it was the sweetest instrument he had ever played upon.

Captain Mair calls the *nguru* a "snorer or nose-flute"; it was made from matai, sometimes stone, was from 4 in. to 5 in. in length, 1½ in. in diameter, tapering internally in exact ratio to the outer surface. The small upcurved end was placed in the nostril when used, the aperture at this end being about the diameter of a lead-pencil. The exterior was fancifully carved, and there were three holes for the fingers of the right hand.

If the *nguru* were played as stated, on what did the air impinge to produce a sound? or what formed a reed? The only way in which the writer is able to sound a *nguru* is by blowing across the wide end as if it were a *koauau;* a clear sharp whistle, almost of piccolo quality, or boatswain's pipe, then sounds, and covering and uncovering the holes gives notes of varying pitch and irregular intervals. The odd hole at the back of the bend altered the pitch, which was high C sharp in an Auckland instrument, about a semitone.

In a note on the *pumoana*, or shell trumpet, which he calls *pukaea* (Plate 69, fig. 1), Captain Mair writes that the wooden mouthpiece was bound to the shell with bark from the hoihere (houhere), or lacebark (*Hoheria populnea*), steeped in a tenacious gum made from the seeds of *Pittosporum*. There is a very old specimen of this trumpet in the Auckland Museum. It is called "Te awa a te atua," and according to tradition was found on the beach at Matata or Te Awaateatua by Tuwharetoa, one of the crew of the "Arawa" canoe. After the birth of the sons of Tuwharetoa his tribe attacked and destroyed the numerous prehistoric people then living about Putauaki (Mount Edgcumbe)- namely, the Kawerau, Te Marangaranga, Te Raupo Ngaoheohe, Te Tinirau, Te Aruhetawiri, &c. A remnant, known as Te Heke o Maruiwi, fled to Taupo, whither they were pursued by the sons of Tuwharetoa, who, having exterminated the Ngati-Hotu, another ancient tribe, finally occupied all that country and are now known at Ngatituwharetoa Elsdon Best notes that the Maruiwi were never located at Taupo. They migrated from the Heipipi *pa* at Petane, marched up the coast, and across the ranges to Opotiki, then on to the Waimana district, where they settled. In later times they were expelled, and returned to Heretaunga *via* Waiohau and Kaingaroa. They were attacked by the sons of Tuwharetoa near Te ahi a nga tane, on the Napier–Taupo road. In panic, they fled in darkness, and are said to have perished in a cañon near Te Pohue, a few survivors reaching Heretaunga. The trumpet "Te awa a te atua" used to be sounded only on the birth of a first-born male child. When Te Heuheu and his tribe were overwhelmed at Te Rapa by a landslip, in 1846, the trumpet was lost, but after many years was found again, and in 1880 given by the late Te Heuheu to Captain Mair. The pitch of the note sounded by "Te awa a te atua" is a shade above lower C sharp; the tone is loud and clear, like that produced from a well-blown cow's horn.

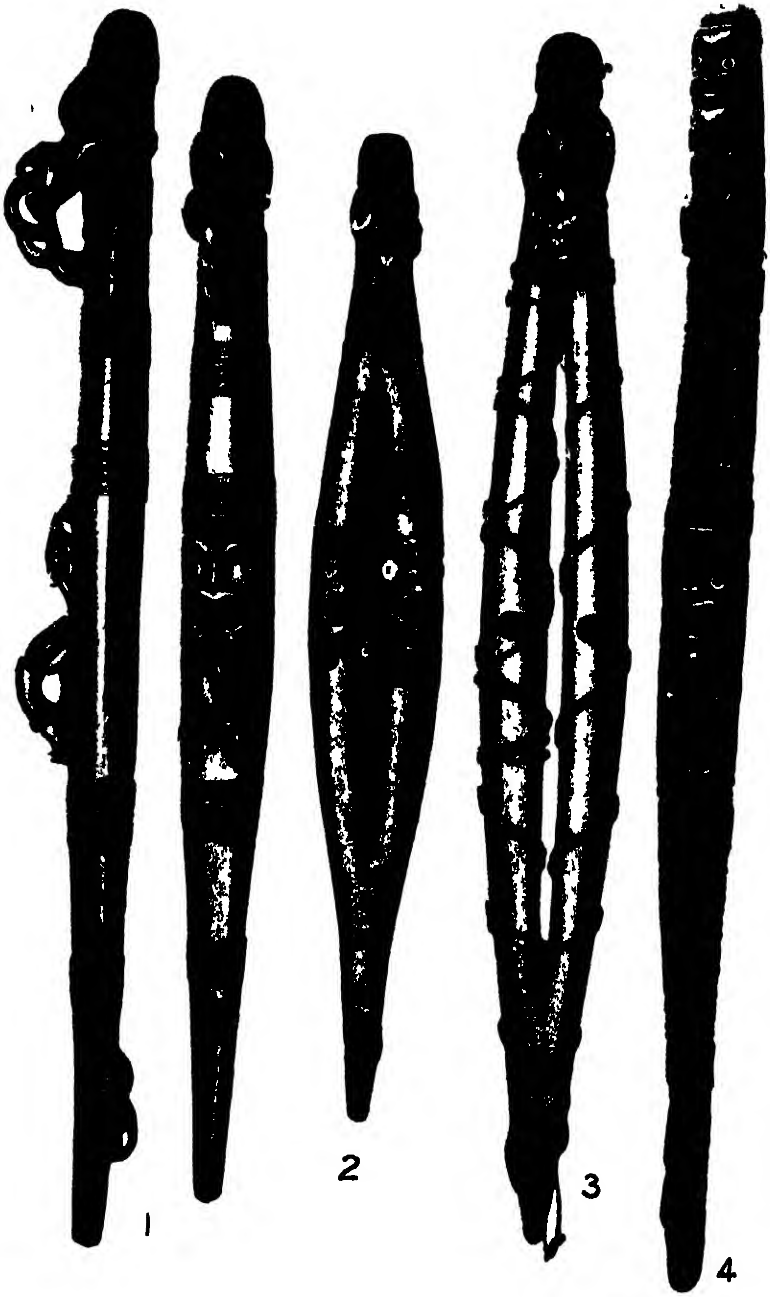
The *putara*, which Captain Mair calls *putatara* or *putatere*, was, he writes, from 5 ft. to 7 ft. in length, and was made of from two to five thin strips of matai hollowed and closely fitted together and strongly bound with kiekie-roots. The mouthpiece was a finely carved human figure, and about 3 in. inside the cylinder was a tongue or valve of wood called *tohetohe* (tonsil). In an example now in the Dominion Museum the tonsil is at the bell end, 11 in. from the extremity (see Plate 69, fig. 2). This trumpet is 56½ in. long, ¾ in. in diameter at the mouth end, 4 in. at the bell.

It is of ingenious construction, the main portion consisting of two pieces of wood (Plate 69, fig. 2, A), being the two parts of a single piece split and hollowed out as described by Captain Mair. To form the belled end, two other pieces of wood (Plate 69, fig. 2, B) have been hollowed and fitted in between the two main pieces like gores. These two pieces are 2 in. in width at the mouth of the bell, and taper to a point at about 17 in. up the side. The rim of the bell has been cut so that it forms a zigzag pattern. (See Plate 69, fig. 2.) At 11 in. from the mouth of the bell a kind of tonsil arrangement has been cut, as shown in the plate. The simple tonsil

[H. Hamilton, photo.

Fig. 1.—*Pukaea* (shell trumpet with feather ornament), in Dominion Museum.

Fig. 2.—Belled end of *putatara* (war-trumpet), looking directly into the instrument, showing *tohetohe* insertion: A, the two pieces of which the main part of trumpet is made; B, the two gores; C, the finer vine binding.



[H. Hamilton, photo.

FIG. 1.—*Putorino* in Dominion Museum: side view and full view
FIG. 2.—Cast of double *putorino* in Dominion Museum; original in British Museum.
FIG. 3.—Double *putorino* in Dominion Museum.
FIG. 4.—*Putorino* acquired in 1923 by Auckland Museum.

projects from one side of one of the broad pieces, the double tonsil projecting from the opposite side of the other broad piece. The right wing of this double tonsil, originally part of the broad piece, has been cut free, so that the double tonsil is connected only at its base, as is the single tonsil. It cannot be determined from inspection if the tonsils have been cut from the original piece of wood, or if they have been set in grooves subsequently to the two pieces being hollowed out: but it looks as though they are actually part of the wood.

The whole trumpet is bound with a split aka-vine of dark-brown colour, a rebate at the mouth end preventing any chance of the binding slipping over the end. The bell is bound with a finer unsplit vine of a much lighter colour (Plate 69, fig. 2, C). The note the writer is able to produce is the bass E. It is not known what purpose the tonsil served. It may vibrate and increase the resonance, but such Maori opinion as can be gathered inclines to suppose that it made the note purer less of a blare. It is said the old performers could almost speak on the trumpet; it is certainly recorded that through it they hurled curses at the enemy with sufficient clearness for the curses to be understood and resented.

There is a fine specimen of the *putara* in the Auckland Museum. It is 76 in. in length, and the chief note it gives is C sharp in the bass This note is exceedingly vigorous and reverberant, and unless the lips are firmly held it gambols in lively fashion both above and below C sharp. This instrument, too, assists the blower to produce the note, and it encourages a vocalization that may well have given the name *putara* or *putatara*.

It is not easy to arrive at an idea of what the Maori thinks of song; nor is this to be wondered at. For one thing, it is a little late in the day to begin questioning. Again, how many Europeans could give definite or satisfactory replies if questioned on the technique of music or song? Writers like Helmholz, on the analysis of sound, or Plunket Greene, on the analysis of song, came at a late period in the development of musical taste—at a date when there is something settled and definite in men's ideas of music and their utterance of it. What can be expected of the Maori, who had not yet reached to the evolution of harmony, to say nothing of counterpoint—who had hardly even reached the stage at which our own enharmonic primitive folk-song evolved?

If we can examine an old poem or song that has escaped the modernizing touch of a Percy, we shall find the phrases of indefinite lengths. In a modern poem or song the phrases are of fairly definite and equal lengths, the full phrase occupying a full verse of eight or seven beats, usually broken into two lines of four beats, or of four and three—the "long measure" and "common measure" of church hymns. Since music followed the words, the four-bar and eight-bar themes in music have their origin in the four and eight accented lines and verses of poetry.

In the old poems, most of which were songs, the lines and verses were not so definitely regular—the regularity finally crystallizing into the stanza of four or eight lines, or of sixteen or thirty-two bars. In singing, the lines took on the character of Gregorian chants, where there are short melodic phrases separated by conventional breves to which an indefinite number of syllables may be sung. .The general trend in singing seems to have been towards the evolution of phrases that could be sung in one breadth, or in two breaths. In church music the old and the new live side by side in the Gregorian chants and the hymns, ancient and modern.

Even in church music, however, the melody is modern throughout in its definiteness—in its being confined to steps of tone or semitone; in the folk-songs the melody, as the rhythm, and the length of the phrases, was *ad lib.* throughout. The introduction of metre and harmony resulted in the standardizing, more or less, of melody, rhythm, and phrase-length.

There is evidence of similar evolution, or trends towards similar evolution, in Maori music. There is also a vigorous survival of what is probably a yet older character—a character that has quite disappeared from modern music. In many if not all the Maori *karakia*, usually sung or intoned in a rhythmical monotone, the whole is delivered on one breath. This would, of course, be impossible for one person, so where two take part one sings as long as his breath will carry the sound, the second takes up the words on the same note just before the breath of the first is expended, so that there is an unbroken flow of sound. When a company of people is singing one of their monotone songs of welcome the break in the general body of sound is quite perceptible when one or other stops to take breath. The one particular voice ceases for a moment or two, then resumes; another ceases, and resumes, and so on, the general murmur never ceasing till the close, where there is usually a drop in the *hianga* through one tone to four or more. The breath may be taken at any place—even in the middle of a word; and, in resuming, the singer may start again in the middle of a word. There seems to have been an aim to make the breath last as long as possible, and there were particular songs for practice in holding the breath.

Dieffenbach writes (*Travels in New Zealand*, vol. 2, p. 32: Lond., 1843): "A very common sport amongst children consists in opening and shutting the fingers, and bending the arm in a certain manner, when the following words are said, the whole of which must be completed in a single breath: '*Katahi ti karua ti ka hara mai tapati tapato re ka rau ua ka rau ua ka hoho te kiwi ku pohe wa tautau to pi to pa ka huia mai ka tako te rangi kai ana te wetu kai ana te marama o te Tiu e rere ra runga e tepe ra peke o hua kauere turakina te arero wiwi wawa ke ke ke te manu ki taupiri.*'"

The division of a song or *karakia* into definite lines, and verses (a definite aggregate of lines), and stanzas (a more or less definite aggregate of verses, usually two or four) is a stage of evolution to which Maori music had not yet attained, but indications of which can clearly be seen. It is a natural evolution to which the poetry and music of all peoples are subject, for the same forms both in poetry and music have evolved independently among the various peoples.

In Maori songs the stanzas are of all manner of lengths, like the old "batches" or "tirades" in songs such as the "Romance of Roland." Among the Ngati Porou these stanzas are known as *whiti*, the divisions within the stanza, the irregular lines, being each called *te upoko:* they are heads. Every song has its principal note, *oro*, the melody rising and falling a little above and below this note. The little drops in fractions of a tone are *whatuinga*. There are often, especially in laments and love-songs—*waiata-tangi* and *waiata-aroha*—curious and affecting breaks, noticed more often on the letter *h*; emotional breaks, introducing a grace-note. This break is called *hotu* ("a heart-note"). It is very noticeable in the songs of Caruso, and with his emotional power behind it it always produces a powerful effect.

The resting-place, or breathing-place, is called *whakataanga*, and there is here often a slight drop, an incipient *hianga*.

The act of starting a song is called *takitaki* or *hapai*. In a song that is sung on one breath the leader will carry on the dominant part or theme, the *tahu*. the chorus coming in before his breath is exhausted. It the song lags, the leader urges the singers by adding volume to his voice —that is *whakarewa*. If a leader or chorus forgets a song, and the *tahu* is broken, that is *ka whati;* the break is *whati*, and is an evil omen. Sometimes, when all is going well, the leader will raise his pitch and sing a tenor harmony: that is *hi*. At Whareponga, on the east coast, a company of women were singing; the song was going briskly and without restraint, and one of the singers raised her pitch, singing very softly a fifth above the others. This was very effective.

There is a word, *irirangi*, which I first heard at Palmerston North when speaking of music to Dr. Buck (Te Rangi Hiroa). He remarked casually that the people often thought they heard a floating voice, or spirit-voice, singing with them; they called it *irirangi*. It was a chance remark, but I remembered it when, at Whareponga, I first heard, as it were, a faint voice sounding above the voices of the women singing. I asked the Hon. A. T. Ngata, who was present, if the faint voice, to which I drew attention, was what they called *irirangi:* he said, Yes; and soon one of the women, who also must have heard it, raised her pitch and sang the same note as the faint voice. Speaking to Dr. Buck again later on, he remarked that the old people would often sing together to get the voice, *te reo irirangi*, and, when they heard it, would sing the song over and over, listening to it. In *Williams's Dictionary*, under *irirangi*, is a quotation,* "*Mehemea ka waiata tatou ki roto i te whare, a ka rangona te waha e waiata ana i waho, he waha wairua, he irirangi tena*" (If we are singing in the house and a voice is heard singing outside, a spirit-voice, that is an *irirangi*). It was said to be an evil omen; but it certainly was not always so regarded. The note heard is a harmonic, and may occasionally be heard when singing on an *ng* sound. At Te Araroa, Bay of Plenty, a woman struck in now and again a third above the others, maintaining the soft harmony not only on the principal note, but also on intricate embellishments. Incipient harmony is indicated, and no doubt all harmony had such simple beginnings; the ear perceives the harmonics before science teaches what they are, and the ear finds them pleasing or otherwise before science explains why. Probably harmonics are heard more commonly than is realized; they may be heard occasionally in the notes of birds, and it is no doubt the harmonics that form the basis of at least some of the morning choruses of the bellbird and tui.

A mellow voice is meant by the expression *puwhawhango*—a voice that sounds as if slightly muted, with just a trace of the effect of singing through a comb—a slightly nasal, resonant quality. The restricted *i* sound (*ee*) is avoided as much as possible, as it makes the sound thin; it is made *e* (as in "net") or *a* if it cannot be avoided or is preceded by *a* to make *ae;* this is especially observed at the head-ends (line-ends).

The motion of the hands during singing is *aroarohaki*, or *aroarokapa*. There is a saying, *Ka kawea e te manamanahau ka aroarohaki* (The singer was so elated by the song that he broke into the appropriate accompanying gestures). There is an infinitie variety of these gestures, and great trouble is taken in prefecting these, certain movements seeming to the Maori to go better with certain types of music. The hands are moved now here, now there, now bending at the wrists, now trembling with the wrists as pivots, now held to the right, now to the left, now close to the body or head, now at arm's length: the knees are bent in rhythmic time,

* Obtained from Elsdon Best.

the foot taps, the head is inclined, the shoulders and the hips sway, the eyes are expressive, the lips—not a portion of the body but enters into the movements. As different songs are sung, one is astonished at the variety of the gestures, and the diffierence of the gestures accompanying the different songs, at the unison of the performers. They give whole-hearted expression to their feelings, whatever they may be, and the listener-observer is continually tempted to join in, so powerful is the effect of the rhythm and the movements and the expression of the music.

I have to thank Mr. George Graham, of Auckland, and Te Rangi Hiroa for much information used in this paper: the Hon. A. T. Ngata and the people of Ngati-Porou for details regarding singing; Mr. Elsdon Best for continual assistance and advice; the Directors of the Auckland, Dunedin, and Wellington Museums for permission to test instruments in their collections; and Mr. H. Hamilton for the extreme trouble taken in making the illustration of the *tohetohe* and the *roria*.

The Early Reclamations and Harbour-works of Wellington.

By Herbert Baillie, Librarian, Wellington Municipal Library.

[*Read before the Wellington Philosophical Society, 18th September, 1923; received by Editor, 19th September, 1923, issued separately, 28th August, 1924.*]

Plate 71.

The story of the discovery, rediscovery, and settlement of Port Nicholson has been fully told by Mr. Elsdon Best and others. It is proposed here to record what was done in the way of introducing shipping facilities and creating the port as at present existing.

The first official mention of Port Nicholson was in a parliamentary paper laid before the House of Commons on the 31st August, 1835, in connection with the recovery of British subjects who had been detained by the Maoris when the barque "Harriet" was wrecked near Cape Egmont on the 29th April, 1834. Captain Guard, of that vessel, with part of his crew and some Maori friends, was allowed to leave the locality to obtain assistance on the 20th June, arriving at Port Nicholson by way of Blind Bay and Queen Charlotte Sound on the 30th June. Here he found the schooner "Joseph Weller," on which he secured a passage to Sydney, where he laid his case before the Governor, Sir Richard Bourke. This resulted in H.M.S. "Alligator" being sent to New Zealand to recover the prisoners. Wellington, or Port Nicholson, only bears on the subject by providing a means for Guard reaching Sydney, but the episode gave Port Nicholson its first advertisement in the British Parliament.

Captain Hobson, later Governor of the colony, visited Cook Strait in H.M.S. "Rattlesnake" during 1837, but he does not even mention the port.

Port Nicholson thus took an insignificant part in the story of New Zealand until 1840; but with the advent of the New Zealand Company the Cook Strait districts and the port showed promise of future

importance. In the Company's prospectus it is stated (1, p. 31) "that Cook Strait, between the two Islands, forms part of the direct track of vessels homeward-bound from the Australian colonies; that many vessels go through Cook Strait, while others at present pass New Zealand at either its southern or northern extremity, but that all would prefer the midway of Cook Strait if that channel were properly surveyed, lighted, and furnished with pilots; and that, consequently, settlements in Cook Strait, at Port Hardy, in D'Urville Island, Queen Charlotte's Sound, Cloudy Bay, and Port Nicholson would obtain stock cattle and other supplies from New South Wales with peculiar facility and cheapness, since homeward-bound vessels would naturally load in part, or sometimes entirely, with stock cattle for New Zealand (and especially on deck in favourable weather, which prevails during nine months of the year), discharging that cargo at New Zealand and reloading there with water and provisions for the homeward voyage, as well as with a New Zealand cargo for Europe, of fish-oil, flax, timber, and other productions of the country." It was also mentioned in the prospectus that New South Wales received part of its supply of flour from the New England States in North America, which New Zealand would be able to supply, taking in exchange British manufactured goods; these the Austalian merchants had obtained by the sale of their wool in London and Liverpool.

At this time Colonel Wakefield, with a small party, was on his way to Cook Strait on the "Tory," with specific instructions (1, p. 23) that he was to select the location of the first colony, to purchase lands, to acquire general information as to the country, and to make preparations for the formation of settlements. The price paid for the land in those days is often held up to ridicule when compared with the present-day value of the same land; but that is the oft-repeated story of the present looking back on the past and envying its bargains. It is repeated even in the story of the early reclamations. What would be thought of land in Willis Street, opposite the *Evening Post* office, being sold at £6 per foot frontage? The speculator of those days did not see any bargain about it; the land—there was only 360 ft. of it—could not be sold; half of it had to be given away; and Sir George Grey did a good turn to the Wellington College when he granted 182 ft. as an endowment to that institution.

The rivalry between Auckland and Wellington, now usually of a fairly friendly nature, is a mystery to many people. It is generally ascribed to the removal of the seat of Government in 1863, but it was in existence long before that. It originated as far back as 1840, when Governor Hobson, without visiting Wellington, selected Auckland as the capital. All sorts and conditions of men, both here and in the Old Country, joined in the discussion of pros and cons. Perhaps one of the most amusing of these was a letter to Lord Stanley from a firm of English lawyers who had been commissioned by several settlers of Auckland to protest against the proposed removal to Wellington (2, p. 68). They state that it would be easy to connect Manukau Bay with the Waikato River, and at a trifling expense. "Taranaki is a fine agricultural district, but it is distant 100 miles from Port Nicholson, and is easier approached from Auckland by means of the River Waikato and Lake Taupo and the River Wanganui than from Wellington. As regards internal communication, there is none at Port Nicholson, which is blocked in on all sides by enormous and

precipitous mountains." There is no doubt that at the time Hobson made his choice North Auckland was the most important part of New Zealand, and the Waitemata district, with its double harbour, was considered a strategical position.

When Captain Hobson and the Colonial Secretary did visit Port Nicholson, although they were badly received, they gauged the position very fairly. Willoughby Shortland, Colonial Secretary, who came to Wellington to suppress a rumoured rebellion, in a report to Governor Hobson (10th October, 1840) says (3, p. 119): "A beautiful and extensive harbour, in which there are no dangers of any consequence; the anchorage in Lambton Harbour is extremely good, but the one off the beach of Petone is by no means safe. A lighthouse and good pilots would in a great measure obviate any difficulties in entering the harbour." During the next year Governor Hobson paid his long-expected visit to Port Nicholson. He had written to the Secretary of State for the Colonies (10th November, 1840) (3, p. 127): "The port is certainly most spacious, and is free from danger within its heads, but its very great extent, and the tremendous violence of the prevailing winds, generate so heavy a sea within itself as to suspend for many days together all operations connected with the shipping. The reports of Mr. Shortland and of other authorities rank Port Nicholson, as a commercial port, second both to the Bay of Islands and the Waitemata (Auckland)." After his visit to the port he reported (13th December, 1841) to the Secretary of State (4, p 183): "As to the capabilities of the port, I am of opinion that few places can surpass it, but the entrance is rather difficult to distinguish, and appears very dangerous to a stranger. A more general knowledge of the coast, however, and a lighthouse on one of the heads, will obviate these difficulties. If any objection to the harbour exists, it is that the estuary is too extended, and the violent winds which prevail occasion a most turbulent sea at the anchorage. Owing to the approach to the shores being shallow, rather long wharves would be necessary." Felton Matthews, Surveyor-General, who came with Hobson, forecasted (4, p. 185) that the best situation for the Customhouse would be between Pipitea and Te Aro, and in front of Lambton Quay, which must be recovered from the water. There it was placed in 1862, twenty-two years after.

The violent winds were regarded from quite a different viewpoint by Bishop Selwyn, who in 1848 wrote (5, p. 46): "No one can speak of the healthfulness of New Zealand till he has been ventilated by the restless breezes of Port Nicholson, where malaria is no more to be feared than on the top of Chimborazo, and where active habits of industry and enterprise are evidently favoured by the elastic tone and perpetual motion of the atmosphere. If I am not mistaken, no fog can ever linger long over Wellington to deaden the intellectual faculties of its inhabitants. They will not always reason right or be unanimous in opinion; but there will always be activity of thought and promptness of action in this battlefield of the north-west and south-east winds."

Lieutenant Wood, late of the Indian Navy, who wrote a rather disgruntled book on early Wellington, has nothing to say against the harbour, but records (6) that "when a beacon is erected on the outermost rock of Barrett's Reef and a lighthouse built upon the Heads nothing more could be desired." He also suggested a "circular wharf abreast the town where vessels of large tonnage might discharge." As will be seen by the harbour-plan, a practically circular wharf, with projections, has been built.

In 1842 the Lords Commissioners of Her Majesty's Treasury approved of Wellington, Auckland, and Russell being constituted free ports in conformity with the provision of Act 3 and 4 William IV. Perhaps this may account for the following Proclamation, dated 1st October, 1844 (7): "On and after this day neither light dues, port charges, nor harbour dues of any kind will be demanded from any vessel whatever in or near any part of New Zealand. Taking a pilot will be optional with the master or commander of any vessel; if used, the charge will be 3s. per foot, into or out of any harbour. There are no duties of Customs or public charges of any kind payable by vessels in New Zealand.- ANDREW SINCLAIR, Colonial Secretary."

BEACONS.

Heaphy in his book (8) says that "much inconvenience has been experienced from the want of lights and beacons." Owing to wrecks in the vicinity of the Heads, the settlers became anxious that beacons should be erected. It may be of interest to show that even then the settlers did not get things on the first asking. The local newspaper of the 16th January, 1841, stated that beacons were to be erected on both sides of the Heads. On the 24th July complaints were made that the work had not been started. On the 4th September another complaint was made. On the 18th December plans and estimates were called for, but nothing was done by the Government until nearly three years later E. J. Wakefield mentions that in 1842 "two landmarks had been put up at the Heads." One, a three-sided wooden pyramid with open sides about 70 ft. high, on Pencarrow Head, was blown down by a gale of wind soon after. This had been put up by public subscription. Another, on the highest peak of the western side of the entrance, Beacon Hill, was more securely fixed, by Colonel Wakefield's orders. It consisted of four tun butts, then three, then one, piled above each other, filled with stones and painted white, with a flagstaff on the top. Tenders were called by the Government in January, 1843, but again there was delay, for it was not until the 20th June, 1844, that it was notified that a beacon had been "erected on Pencarrow Head, at the eastern side of the entrance to the harbour, bearing, from observations taken on board H.M. colonial brig "Victoria," S.E. by E.½E. from the outer rock of Barrett's Reef, 37 ft. high, painted white and surmounted by a red flag." On the 17th February, 1854, the Provincial Council's Harbour Light Committee reported that it had visited Pencarrow and had found that the beacon was quite unsafe, the bottoms of all the upright planking having become quite rotten. There was danger of it being blown on to the light-keeper's cottage during a southerly gale. "It ought to be whitewashed to render it more conspicuous, and generally, whatever improvements are contemplated, ought to be effected directly while the weather is fine, and finished before the winter." Also, in 1854 the House of Representatives set up a Committee to consider the matter of erecting beacons and lighthouses. It suggested that a beacon be erected on the outer rock of Barrett's Reef, with a reflector so placed, if possible, as to catch the light from the lighthouse on Pencarrow. While the permanent lighthouse was being erected in 1858 it was found necessary to remove the beacon. A temporary flagstaff was raised, carrying a white flag with a red ball above it. The lighthouse was painted white, and thus became a beacon by day as well as by night. The *Wellington Almanac* of 1845 does not mention the beacon, although it mentions the signal-station on Mount Albert. In Grimstone's *Southern Settlements* (1847) the

sailing directions by Captain Richards, of the "Victoria," note the white beacon on Pencarrow, and the landmark on Beacon Hill. The *Cook Strait Almanac* of 1851 mentions that the Pencarrow beacon is not visible at a distance of five miles, except in clear weather. The *New Zealand Pilot* of 1856 mentions the barrel beacon, also the Pencarrow beacon, but not the red flag. In the *New Zealand Pilot*, 1856, the Government House flagstaff is noted as a leading-mark, also the "Waterloo Inn," a large white building on the extreme of Kaiwarra Point.

Signal-stations.

The first signal-station was erected on Mount Albert, the peak to the south of Newtown Park, in 1844. The first signalman was Robert Houghton, a master mariner, who was also gazetted as keeper of the powder-magazine. The signals used in those days were the same as now used at the Mount Victoria Signal-station, though some of them have fallen into disuse. One that would be frequently used in the "forties" and "fifties" the circle, for a brig—has probably not been used for many years. Until the days of regular steam communication with the Home-country the square, the signal for a ship, was an important signal to those who were expecting friends or important cargo, and they anxiously awaited the hoist of flags denoting the particular ship signalled. Cases were known, however, of vessels, though signalled, being delayed for days by adverse winds and weather. From the 13th September, 1849, the signals from Mount Albert were repeated on the flagstaff* which had been erected in front of the old Government House at a cost of about £100. In February, 1863, Mr. John T. Platt offered to repeat the signals on a flagstaff that he had erected at the foot of Tory Street. His letter, published in the *Provincial Gazette*, stated that the staff was erected on his premises known as the "Brick House," and that "the signals would be repeated with accuracy and regularity. The signals would be of sufficient size and would be placed at sufficient height as to enable them to be seen clearly by the greater portion of the inhabitants of Te Aro." Apparently the service was not satisfactory, as a petition was presented asking the Council to provide a station for Te Aro, or improve Platt's. The change to Mount Victoria rendered any repeating within the town unnecessary.

While the signal-station was on Mount Albert the outside pilot-station was in a small cove a little to the west of Palmer Head, Tarakena Bay. On the 26th December, 1858, the Consulting Engineer, Mr. Carter, reported that the signal-station was in such a bad state as to remind one of the celebrated gun that needed a new lock, stock, and barrel. In 1866 it was decided that the pilot service should be located within the Heads, Worser Bay being the position selected. Land was purchased and buildings erected, some of which are still in existence. A signal-station and a dwelling for the signalman were erected on Beacon Hill, and the signal staff was removed from Mount Albert to Mount Victoria, to which the signals were repeated from the outer station. Code-flags, both Commercial Code and Marryatt's, had been supplied, and by their means messages could be sent from town to vessels, the pilot-station, or the lighthouse at Pencarrow, or *vice versa*, by way of Mount Victoria. Later,

* An illustration of the first Government House, with flagstaff before it, appears at p. 21 of the *Cyclopedia of New Zealand*, Wellington Provincial District, 1897.

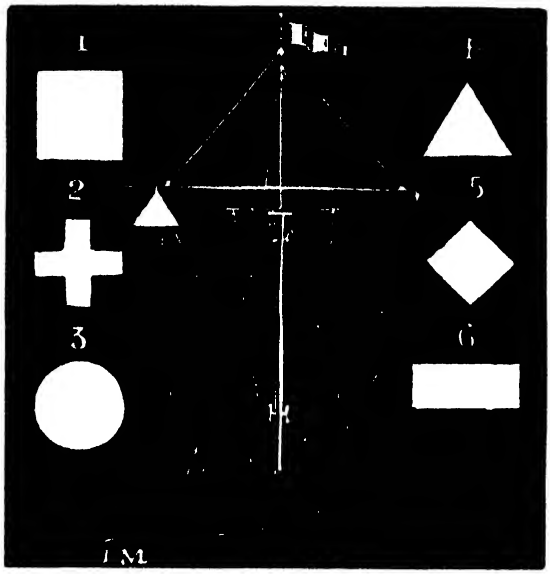


FIG 1.—Signal-station on Mount Albert (from print in Alexander Turnbull Library) No 1 denotes a ship, 2 a barque, 3 a brig, 4 a schooner, 5 a cutter, 6 a steamer.

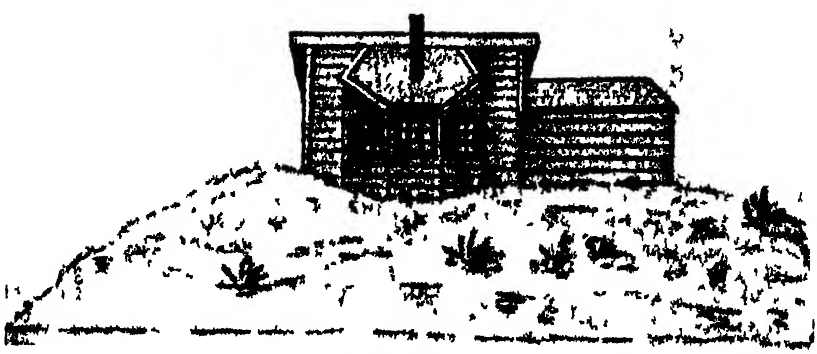


FIG. 2.—First lighthouse at Pencarrow Head. (Original sketch in possession of Mr. F. J Halse.)

Beacon Hill became what was known as a learners' station, with a Morse telegraph-set connection with the Wellington Telegraph Office, a cadet being stationed there. Still later, a telephone was installed between the pilot-station and Beacon Hill, one of the first telephone circuits in New Zealand.

The first pilot appointed by the Government, in 1842, was D. McCarthy. James Hebberley had been appointed by the New Zealand Company in 1840. McCarthy was succeeded by R. Calder, who retired in 1848. He was succeeded by James Ames (father of the present City Valuer), who filled the position temporarily. In 1849 Captain Daniel Dougherty, an American whaling captain, was appointed, and he held the position until his death in 1856.

It should be mentioned that Heaphy records (8) that "E'Warri, one of the young chiefs of Port Nicholson, had, with a boat's crew of Natives, gone off to the "Olympus," immigrant ship, in the strait during a gale, and piloted her with safety into the harbour, and to an anchorage, for which service the company awarded him £5.

Time-signals were given daily from H.M. Surveying Ship "Acheron," Captain J. L. Stokes, while in port towards the end of 1849. On the 9th March, 1864, a time-ball service was instituted. A mast was raised above the Customhouse, on which a large black ball was raised daily, half-mast at ten minutes to 12, mast-head at five minutes to 12, and dropped at noon, Wellington mean time. The cost of the astronomical clock ordered in connection with the time-ball, with the other necessary apparatus and fittings, amounted to £941 12s. 7d. The first observer was the Rev. Arthur Stock, of St. Peter's Church.

LIGHTHOUSES.

The first mention of a proposed light was the offer of the New Zealand Company, on the 5th November, 1841, to erect a lighthouse on Pencarrow Head, at a cost of £1,500, provided that such sum should be a charge against future dues (2, p. 31). The Colonial Office referred the matter to the New Zealand officials. Whatever the reply may have been, there was no lighthouse erected by the company. Perhaps the following extract from Wakefield's *Adventure* (9) should have been the first paragraph of this section although the lights referred to were hardly what is known as a lighthouse: "The frigate sailed away on her return to the Bay of Islands the same evening, beating out in the dark against a fresh breeze with her boats holding lights on the extremities of the reefs." The frigate was H.M.S. "Herald," Captain Nias, which had called at Port Nicholson on the 20th July, 1840, on her return from a mission to declare British sovereignty over the South Island, and also to secure signatures to the Treaty of Waitangi. When the beacon was erected in 1844, the question of a lighthouse was left in abeyance until 1852, although public opinion had frequently called for one as a necessity. The necessity was emphasized by the wreck, on the 23rd July, 1851, of the barque "Maria," Captain Plank, from Port Cooper, which ran ashore near the mouth of the Karori Stream and became a total wreck, twenty-nine lives being lost. The absence of a lighthouse was held as being chiefly responsible, and a strong appeal was made to Sir George Grey that one should be erected at once. He agreed, and proposed that the duty on spirits should be increased by 1s. 6d. per gallon for the purpose of raising the means to do so. The proposal was carried, but still no lighthouse—no real lighthouse. Mr. C. R. Carter, in his *Life*,

says: "Instead of a proper lighthouse being erected a miserable shed with a bow-window in it was constructed, in which was placed an indifferent lamp-light." In 1853, Carter had occasion to visit Wairarapa, which he did by walking to the old pilot-station by way of Lyall Bay and crossing to Pencarrow in the pilot-boat. He ascended the hill on which the "lighthouse" stood (10). "From here I saw the lighthouse-keeper (Mr. G. W. Bennett) coming up the hill with a load of drift-wood on his back which he had collected on the beach, and looking like another 'Robinson Crusoe.' This Government officer or servant had his habitation—I cannot say it was a comfortable one, many would call it a wretched place; but, Lord bless me! man is an animal that accommodates himself to all sorts of odd things and contrarieties, from the peer in his palace to the savage in his hut. Here was a case in point: Governor Grey lived in Government House, built on a nice green mound; the lighthouse-keeper also lived on top of a hill, and, with his wife and three children, and the lighthouse apparatus, were all stowed away in two little rooms each about 10 ft. square and without a fireplace. The interior of this building, a lighthouse and dwelling combined, was accessible to wind and rain on all sides, and in heavy gales it rocked and shook so much as to frighten the keeper and his family out of it, who in that case took refuge in a sort of cave or cabin which he had scooped out of the side of the hill, over which he had fixed a rude thatched roof and in which he had built a rude stone chimney. This cabin was his house of refuge and his cooking-place." Mr. Carter, in a note, states that Mr. Bennett was drowned some time afterward, he thinks by the upsetting in a storm of the pilot-boat which was about to land him at Pencarrow.

One of the first Committees to be set up by the House of Representatives was one appointed (22nd June, 1854) to report on the lighthouses and beacons required on the coast. It reported on the 8th August, 1854. Pencarrow is mentioned as being only a temporary light of an extremely inferior description, even considered by an authority as being likely to mislead navigators. The Committee recommended that a permanent lighthouse be erected as planned by Mr. Edward Roberts, of the Royal Engineer Staff, then stationed in Wellington, the estimated cost to be £3,400. Captain Drury, of H.M. Surveying Ship "Pandora," in giving evidence before the Committee, recommended that the light be placed on Point Dorset. The Provincial Council had during its first session appointed (23rd December, 1853) a Harbour-light Committee, which reported (17th February, 1854), in part, as follows:—

"The establishment (Pencarrow) was visited 4th February, 1854, and all things found clean and in order, and very creditable to the person in charge. The situation is considered the best that could be chosen for the first harbour-light, answering at the same time the useful purpose of assisting the navigation of that part of the strait adjacent to the Heads. The apparatus for producing the light is not very powerful, but with some slight modification might be made far more effective.

"The great complaint is that towards morning the light gets so dim and discoloured as to become scarcely visible. This arises, in the first place, from the inferior quality of the oil, by which the lamp gets clogged up before morning and the quantity of light greatly lessened; and, secondly, from the position of the smoke-conductor, which is thereby rendered useless, and the room, being kept constantly full of dense smoke, the windows become completely blackened in a few hours, thereby producing that glimmering red appearance which all have observed a few hours after the lamps have been

lighted. By using a better oil a superior light would be produced and kept up till morning; and by removing the present conductor, which is placed far too low, and making two apertures in the highest part of the ceiling, one at each corner, to act alternatively in case of a change of wind, the smoke would be got rid of, and the same or nearly the same brilliancy kept up till morning which is now seen only in the early part of the night. There is no doubt but that the conflicting testimony respecting the light has arisen from the different appearances presented to individuals in those different hours of the night in which they have had an opportunity of seeing it. The only other alteration the Committee recommend would be to place the present apparatus for producing the light upon a revolver which might be erected and worked in the present building at a small additional expense, thereby giving the light a distinctive character and preventing its being mistaken for a casual fire, without diminishing its force by the intervention of any coloured medium.

"The Committee also recommend that a supply of oil, &c., for the light, equal to one month's consumption, should be always kept on hand, as they are sometimes, under present arrangements, without oil, and, should the weather be tempestuous, might be so for weeks, to the great danger of ships frequenting the harbour.

"The house appears to be strongly built but quite unfinished, being neither wind or water-tight, and, as it is so exposed, something should be done to make it more habitable before the winter."

In the *Wellington and Coast Almanac* of 1855 it is stated that at night a light is shown but it is not seen at more than two or three miles. The *New Zealand Pilot* of 1856 ignores the light.

During the fourth session of the Provincial Council, 1856–57, it was decided to erect a permanent light. The sum of £10,000 was voted for the purpose, being part of a loan to be raised. Previous to the vote being passed the Superintendent wrote to the Colonial Secretary requesting a copy of all correspondence, with the plans and specifications prepared by Mr. Roberts. These contain much interesting information about the proposed lighthouse. On the 26th March, 1857, the Superintendent wrote to Mr. Edward Roberts, who had by then returned to England, forwarding plans and specifications as prepared by him in 1853, asking him, with Mr. James Smith, a Wellington citizen then in England, to obtain and send out the building with all its fitments, light-apparatus, &c., all mechanism to be duplicated. The sum of £3,500 was fixed as a limit to cost. The contractor was to erect the building and fix apparatus, and if the person sent out was a lightkeeper he could be appointed to take charge of the light. The tenders received ranged from £2,435 to £2,823, the successful contractors being Messrs. Cochrane and Co. In opening the fifth session (2nd June, 1857) the Superintendent stated that the General Government had objected to the Provincial Council constructing the lighthouse, as the 19th section of the Constitution Act prohibited any Provincial Council from making any law for the erection and maintenance of lighthouses. The Superintendent questioned the ruling—it only applied to lighthouses on the coast. He reminded the Council that they had maintained a light at Pencarrow for several years. In any case, he had ordered the lighthouse, and he hoped that it would be landed during the course of the next six months.

Though out of chronological order, it may be noted that one of the reasons for the disallowance of the Municipal Corporations Act, 1842, by the Colonial Office was, "by the sixth clause the Corporations are authorized to erect

beacons and lighthouses, a power which properly belongs solely to the Crown." The directors of the New Zealand Company protested against the disallowance, and, in respect to the above objection, submitted that there did not seem to be any objection, upon principle, to allowing the representatives of the community to execute public works of that nature respecting the call for which, the proper sites of their erection, and the best means for compassing that end, the representative of the Sovereign, residing at a distance, must be comparatively ill-informed.

Also out of chronological order, but very interesting and opportune, is the following extract from the *Evening Post* of the 13th July, 1923:—

PARLIAMENT.—TO-DAY'S PROCEEDINGS.

Legislative Council.

In the Legislative Council to-day Sir Thomas Mackenzie asked the Attorney-General whether the time had not arrived for the erection of an automatic light on Barrett's Reef, at the entrance to Wellington Harbour, in order that greater safety may be given to navigation. He said that some forty masters of steamers had petitioned to have a light placed on the reef. The reef was exceedingly dangerous in foggy weather.

In reply, Sir Francis Bell, Attorney-General, said Barrett's Reef was within the limits of Wellington Harbour, and the question of placing a light on the reef was a matter for the Harbour Board to determine.

According to a return dated 15th May, 1858, the total cost up to that date, including the salary and passage of Mr. Edward Wright, who had been sent out to superintend the erection, amounted to £2,554. Mr. Wright reported on the same date that the cost of erecting the lighthouse, if landed at Fitzroy Bay, would be £750; if landed inside the harbour, two miles and three-quarters from Pencarrow, the cost would be £2,000, exclusive of landing the material on the beach at the selected point. In a return to the General Assembly, 1867, the total cost of Pencarrow to date was stated to be £6,422. The light was exhibited from the 1st January, 1859. It was described as being of the second order, catadioptric system, with eclipses at intervals of two minutes. The cause of the change to a fixed light from September of the same year has not been traced; it was probably some trouble with the mechanism. The first keeper of the light was Mrs. Bennett, widow of the first keeper of the temporary light, with W. Lyell as assistant. In the 1865 report of the Marine Board Engineer, Mr. Balfour, Pencarrow is referred to: "While engaged in a survey of the strait we happened to pass Pencarrow at night, and, as the light was very poor, we landed to examine it. We found everything in good order except the light, which, though very white and clear, was miserably low, being only 1½ in. from the burner to the top, whereas the standard height is from 3½ in. to 4 in." He suggested that the services of the trained light-keeper who had been brought out by the Provincial Council of Otago should be secured in order to examine and adjust the apparatus and instruct the keepers. In 1867 the Engineer reported that the roof of the keepers' cottage had been blown off during a gale. He also suggested that a better path to the lighthouse be formed, and that a store be erected on the beach, also one on the hill, which could be used as a workshop. During that year £298 was expended, so probably his suggestions were agreed to. A new set of lamps were installed during the year 1869–70. The Marine Engineer, on the 18th June, 1869, reported that the buildings were much decayed. During the following year new dwellings for the keepers were erected at a cost of £764.

In 1864–66 the Marine Act of 1863, which imposed duties on the provinces in connection with lights and beacons, was amended. The Marine Board was abolished, and the Provincial powers in connection with lights and beacons withdrawn, the powers being vested in the Governor, who was also given authority to purchase any of the lights and beacons from the Provincial Governments. It would probably be at this time that the management of Pencarrow passed to the Marine Department.

In 1864 the Chamber of Commerce urged that a light be placed on Point Gordon, but the President of the Marine Board pointed out that Somes Island would be a better position, therefore it had been decided to erect a lighthouse there. It was erected and maintained by the Provincial Council until the abolition of the provinces, in 1875, when the Marine Department took over the responsibility and expense until a few years ago, when they were passed on to the Harbour Board. The light was first shown on the 17th February, 1866. It was manufactured by Messrs Chance Bros. and Co., and described as being catadioptric, of the fourth order, showing a fixed white light in mid-channel, a fixed red light on the western and a fixed green light on the eastern shore. Keepers' dwellings were erected in October, 1865, at a cost of £695. Some trouble was caused at the outset owing to the divisional lights not working satisfactorily. Mr. W. Lyell, transferred from Pencarrow, was the first keeper, with D. Susans as assistant.

Colza-oil was used by New Zealand lighthouses until 1872. The Marine Department report of that year suggested a change to kerosene, which would result in more brilliant lighting at a reduced cost. In 1876 the report gave details of the illuminating-power of kerosene. In 1877 Pencarrow and Tiritiri were the only lights using colza. In 1881 kerosene lighting was completely installed. In 1878 Pencarrow consumed 510 gallons of colza, in 1881 734 gallons of kerosene. During the financial year 1921–22 867 gallons were used. It may be of interest to note that the cost of oils and wicks in 1857 was: Lamp-oil, 10s. per gallon; sperm, 5s. 10d. per gallon; cotton wick, 10s. per pound.

According to a return, the Government secured the freehold of the lighthouse reserve, consisting of 69 acres, from the Maori in 1873, although in 1841 it was notified that the Government has reserved land at Pencarrow for public service.

THE "INCONSTANT."

Towards the end of 1849 the ship "Inconstant," 588 tons, of London, missed stays in entering the harbour and drifted on to the rocks at the point near Pencarrow named after her. Fortunately, H.M. Surveying Steamer "Acheron" was in port at the time and towed her off. Apparently the damage was too extensive for repairs to be effected, for Messrs. Bethune and Hunter sold the vessel to a local shipwright, who in turn sold it to Mr. John Plimmer in 1850 for £80. Mr. Plimmer received permission from Sir George Grey to remove the vessel from Te Aro, where she was beached, to a short distance north of Clay Point, in front of Barrett's Hotel, by that time removed to its present site. He cut down the upper works, shored up the hull, connected it with Lambton Quay by means of a bridge, and constructed over part of it a large building, 68 ft. by 30 ft., comprising two floors, while the lower part of the ship formed a basement measuring 80 ft. by 25 ft. The building was fitted as a warehouse and auction-room for Messrs. James Smith and Co., who opened it for business on the 14th May, 1851. As usual in those days, the occasion was celebrated by a lunch. The building was generally known as "Noah's Ark," although it was often

called "Plimmer's Wharf." There was an open platform at each end of the hull. The fore part of the vessel is said to have rested in 10 ft. of water, the platform being used as a wharf. The earthquake of 1855 caused some damage by throwing the vessel on its side, but with difficulty it was replaced firmly and safely in its old position. After the shake Mr. Plimmer built a retaining-wall to the north of the "Ark" and filled in around it. Mr. C. R. Carter, in reporting on Mr. Plimmer's claim in 1862 for the pre-emptive right to purchase the adjacent land, stated that Mr. Plimmer had constructed a timber breastwork 136 ft. long, valued at £95, and had filled in 3,601 cubic feet of spoil, valued at £450. The Provincial Council allowed Mr. Plimmer's claim to two sections. These sections together comprised an irregularly-shaped block with a frontage of 50 ft. to Hunter Street, 130 ft. to Customhouse Quay, and 130 ft. to Lambton Quay. The price of the Hunter Street corner section was to be fixed by the price obtained for the section opposite—that is, the present Australian Mutual Provident Society's site. The second section, with 70 ft. frontage to Customhouse Quay and 130 ft. to Lambton Quay, was to be sold on the Customhouse Quay frontage at a price per foot averaging the price received from the sections on the opposite side. This land brought £15 per foot. He was also to be allowed the amount stated above for the work done by him. After the 1861 reclamation was completed Mr. Plimmer constructed another wharf from the breastwork. This wharf was generally known as Plimmer and Reeves's Wharf. It was the last private wharf in Wellington Harbour to go, which it did when the Te Aro reclamation was undertaken.

Harbour-lights.

The first official harbour-light was a red light shown from the end of "Noah's Ark" on and after the 6th November, 1858, "for the guidance of vessels coming in to an anchorage in Lambton Harbour." At this time the Harbourmaster had his office at Plimmer's Wharf—"Noah's Ark." A white light was shown from the deep-water wharf on the 19th October, 1863, but it was placed so low that complaint was made that it was hidden by any vessel that might be lying at the end of the cross-head. In 1866 the Harbourmaster reported that a better light should be shown on the wharf, one that could be seen at a distance of four miles in ordinary weather, the present light being visible only half a mile. On the completion of the extensions in 1867 a powerful red lamp was placed at the end of the wharf.

The 1858 Harbour Regulations provided that all vessels should have buoys and buoy-ropes to their anchors to show their position; also that all vessels should hoist a conspicuous light at their peak-end from dark to daylight. This latter regulation came into force on the 23rd December, 1858. One of the local papers of the following day remarked on the picturesque and novel sight.

Reclamations and Sea-walls.

In 1847 tenders were called by the General Government for the construction of a timber breastwork along part of Lambton Quay. Tenders were to be marked "Tenders for repairing Beach Road." In the early days of the settlement the waterside road was known as "Thorndon Quay" from the Hutt Road to Charlotte Street, and "Lambton Quay," from thence to Section 205, where Willis Street

commenced. Locally, the full stretch was known as "The Beach." Along the quays the water at high tides in many places covered part of the roadway, and probably it would be to form the roadway in one of these bad places that the breastwork was required. Even in 1850, Carter tells us, there was not room in some parts for two carts to pass. In 1854 Carter constructed for the Provincial Government another breastwork, 600 ft. long. It was constructed of brick, and, he says, was built with the object of widening the beach to a width of 60 ft. This contract, which also included the formation of a footpath and cross wood drains, cost £832. Mr. Edward Roberts was instructed in 1851 to prepare a scheme of reclamation. The *Spectator* proposed that it should extend from Pipitea to Clay Point.

In 1852 the Government of New Munster, which comprised the southern half of the North Island and the whole of the South Island, called for tenders for reclaiming a part of Lambton Harbour. This reclamation is generally known in legal circles as "Sir George Grey's reclamation." It ran from Customhouse Street (now usually known as "Old Customhouse Street") 360 ft. north, with a depth towards the harbour of 100 ft., the frontage being to Willis Street. Mr. Roberts was Engineer, and C. R. Carter secured the contract, his tender amounting to £1,036. Work was commenced early in April, and was completed early in October. Apparently the land was offered for sale as it became available, for a block was put up for sale by public auction on the 21st July, when a 50 ft. frontage was sold to John Harding at the upset price of £6 per foot. On the 11th September another block, of 60 ft., was sold at the same price to S. Cimino. There was to be another sale on the 30th October. I can find no record of the sales on that day, but, through the kindness of Mr. Maurice Smith (Chief Draughtsman of the Survey Department), I learn that the total sales to the public amounted to £900. This accounts for 150 ft.; 182 ft., with an area of 1 rood 25 perches, was granted by Sir George Grey as an endowment for the Wellington College. There was a cross-street from Willis Street to the waterfront (now part of Mercer Street), of a width of, say, 28 ft., which would account for the full frontage of 360 ft. as per contract. The value of the College Reserve would be £1,092, making a total value of £1,992 against an expenditure of £1,036. The cross-street was officially known as "College Passage," although later it was known as "College Lane"—now Mercer Street. Carter records that during the progress of the work a heavy sea carried away part of the wooden wall; he also records that his profit amounted to £212, although the Engineer assured him before he signed the contract that he had underestimated the work. During low tides the water would probably not be near the wall.

By the Public Reserves Act, 1854, the Provincial Government was granted the right to reclaim part of the harbour below high-water mark from the "reclaimed land" to the foot of Tinakori Road. "Reclaimed land" would, of course, refer to the 1852 reclamation A definite scheme of reclaiming land from the harbour was asked for, when the Committee on the Harbour Reserves Bill reported to the Provincial Council (1st February, 1856), as follows:—

"Your Committee has been unable to obtain sufficient information to enable it to propose any specific plan for the management of the harbour reserves. It therefore contents itself with recommending that the Superintendent should invite, by competition, plans and specifications for the reclaiming of the land and building retaining-walls, and having especial reference to the practicability of carrying out the works in separate blocks,

such plans to be accompanied by a plan for laying off the reclaimed land in streets, and for drainage. That in all plans a continuation of Willis Street and a quay on the water side be made main features. That the Superintendent should offer a premium for the plan which he may consider the most practicable. That blocks of the land be sold unreclaimed under a condition that the purchaser shall reclaim within a certain period, according to the adopted plan, or the Superintendent should contract with persons willing to do so. To reclaim any block or blocks, the contractor receiving payment for so doing on sale of the land, the amount of the contract being added to the purchase-money as for improvements thereon or, if the block be sold in lots, apportioned among the purchasers accordingly. That sufficient reserves be made for public purposes. That all land alienated, except that hereafter referred to, be absolutely sold, and that by public auction. That those persons who have erected wharves along the beach, extending unto the reserved land, should have the right of pre-emption over the allotments comprising such wharves, at the average price of the adjoining land."

An Act was passed during that session enabling the Superintendent to act as suggested, also giving him authority to grant a lease of a section with 80 ft. frontage to Willis Street, at such rent and on such terms as he might consider expedient, to the Tradesmen's Club, which appears to have been an institution of the nature of a Chamber of Commerce. It proposed to build a public hall, and also to erect and maintain an inner harbour-light, "the water frontage admitting of so useful an appendage," there being no harbour-light at the time. The suggestion to have a quay on the water side was not adopted, thus giving purchasers the water rights at the rear of their sections as far as the Willis Street and Customhouse Quay sections were concerned. To extinguish these rights the City Council had to grant compensation to the owners at the time of the Te Aro reclamation. Apparently it was proposed to erect a stone wall, for tenders were called during 1856 for the conveyance of 2,000 tons of stone from Somes Island to where they might be required between Bowler's Wharf and "Noah's Ark." "The stone will be put on a jetty at Somes Island, alongside of which there will be a depth of 5 ft. at high water. Deliveries to be of not less than 200 tons per week, to commence 18th December, 1856." Engineers may be interested in the subject of Somes Island stone, though this scheme was not proceeded with. Carter writes: "Towards the end of 1857 I succeeded in getting a contract for building a long length of brick-in-cement sea-wall, which commenced at the north end of the wood retaining-wall I had previously built (Chew's Lane), and extending into water 3 ft. deep at low water to near Clay Point at 'Noah's Ark.' My contract for this (which included 172 ft. of brick sewer) was £3,343. In the year 1861 I obtained another contract for continuing this sea-wall on to a point in a line with the northern side of the block of land on which the Oddfellows' Hall is built. Both of these contracts, though very difficult to execute, proved to me very remunerative. The 'gossipers' said I would have to go to the expense of coffer-dams in order to lay the foundations under water. They were mistaken. I devised a plan of building (out of water, but over their sites) large blocks of brickwork loosely keyed together, and then lowered them into their position or site under water. I then keyed them with large bricks, and as at low water the tops of the blocks were about 6 in. out of water, I built upon them without much difficulty except when the water was rough." The filling-in of this space was carried out by day

labour at a cost for the first part of £2,237, totalling £5,580 for that block. The first sale of sections was advertised for the 14th May, 1858. It covered twenty-five sections with frontages to Willis Street, Harbour Street, Customhouse Quay, and what is now known as the Bank of New Zealand corner. The total frontage offered was 844 ft., costing approximately £6 10s. per foot frontage. Sections in Willis Street were priced at an upset value of £12 per foot, Harbour Street at £4, corner sections £8, Customhouse Quay £15, while the Bank of New Zealand corner was fixed at £8, totalling £9,712. Nine out of the ten Willis Street sections were sold, three out of the eight Harbour Street sections, while none of the Customhouse Quay sections, nor the corner, were disposed of. The unsold sections were offered again on the 1st September, 1858, but apparently none were sold, for they were offered yet again on the 5th March, 1862. The size of the Bank of New Zealand section had been increased to 70 ft. or 71 ft. to Lambton Quay with 100 ft. to Customhouse Quay. The upset price was £8 per foot, Lambton Quay frontage, at which price the Bank of New Zealand was the purchaser. It should be noted that the law provided for the sale of the reclaimed land by the Provincial Council only by auction and for cash. It should also be noted that in the March, 1858, session of the Council Mr. Richard Barry, a member for the City of Wellington, proposed that the land should be leased, but he received no support.

In February, 1866, Mr. W. Tonks, who had secured the contract to reclaim 13 acres of land from Panama Street to the north of Waring Taylor Street, including the construction of a sea-wall, for the sum of £24,792, commenced the work, which was to be completed in June, 1867. The area of the 1857–63 reclamation to Panama Street was 7 acres 3 roods 34 perches, the total cost was £15,443, and the proceeds of sales amounted to £37,529. The area of the 1866–67 reclamation was 12 acres 3 roods 29 perches, the cost £25 028, while the proceeds were only £8,923, but to this should be added the amount paid by the City Council for the unsold sections.

Soil for filling in the different reclamations was obtained from the hillside at the rear of the Quay sections, Kumutoto (Woodward Street) to Boulcott Street, Mr. Tonks even proposed to lay a tramway by way of Manners Street and Cuba Street to Webb Street to bring spoil from there. Permission was granted by the Town Board, but he only used the tramway from Willis and Boulcott Streets, also a tramway from Kumutoto. The 1857-61 reclamation was filled in with spoil brought in carts. In the original plan there was no street running parallel with Customhouse Quay, but in July, 1864, the Council decided that such a street should be formed, opening in front of the Supreme Court, Lambton Quay, to be known as Featherston Street, in honour of the Superintendent.

In addition to the public reclamations, permission was granted to the Oddfellows to reclaim a section fronting Lambton Quay. This section was recently sold by that body. The foundation-stone of the Oddfellows' Hall on the reclaimed land was laid on the 21st May, 1859. The Foresters were also granted a site in 1864—the next section to that now occupied by the Government Fire Insurance Building, which, by the way, stands on a section, 100 ft. by 100 ft., reclaimed by Messrs. Joseph and Co. in 1865, at a cost to the firm of over £300. The Freemasons were also granted a site for reclamation, but apparently they did not take advantage of the grant.

In 1864 it was decided that in future all streets should be 100 ft. wide, which accounts for the extra width of a part of Lambton Quay.

In 1871 the Provincial Council agreed to sell all of the unsold sections of reclaimed land to the City Council for £12,000. Needless to say, it was a bargain for the city, and the City Councillors of that date are entitled to the gratitude of subsequent generations. The Council was wise, and did not attempt to part with the freeholds, excepting some taken over by the General Government.

In 1873 the Provincial Council agreed to convey to the General Government nearly 3 acres of unreclaimed lands for the purpose of erecting Government Buildings and for railway purposes at Pipitea.

During the same session, on the motion of Mr. Edward Pearce, it was resolved that the Council recommend that the tract of land covered with water, extending from Te Aro Flat to Lambton Harbour, comprising 70 acres or thereabouts, be granted to the City of Wellington to be reclaimed from the sea. The resolution was approved by the Superintendent. This is the block known later as the Te Aro reclamation.

On the 5th March, 1875, the Provincial Government entered into an agreement with the Wellington City Council to sell to the latter body its rights in connection with another block of land then being reclaimed under contract with Edmund O'Malley, containing an area of 36 acres, for the sum of £30,000 with outstanding liabilities on the block, and also cost of work from date till taken over by the Corporation, less moneys due from the General Government on account of land acquired from the Provincial Government. The signatories on behalf of the City Council were Joe Dransfield and E. T. Gillon (Councillors). This agreement was never carried out, and apparently the General Government took over the whole contract, and the City Council lost a bargain. For this reclamation jarrah piles were used as a breastwork, and the spoil was brought from the foot of the Wadestown hill, where the oil-stores are now situated. Ballast-trains were used. The spoil for the Te Aro reclamation came from FitzGerald Point and the Roseneath Hill. Particulars of the Te Aro reclamation are easily obtainable, and, with those of the Kaiwarra reclamation, now in hand, are left to the future historian.

Wharves.

General.

In the Wellington Harbour Board *Year-book* issued in December, 1921, there is recorded a list of the piers or jetties, including Brown's, Rhodes's, Moore's, and others, constructed during the early years of settlement, which may be accepted as substantially correct. The following notes are supplementary to those in the *Year-book*, which were compiled by Mr. Elsdon Best.

The Commercial Wharf, unlike the other early wharves, was constructed by a public company with a capital of £250 in £2 shares. The wharf was completed in December, 1841. It accommodated vessels up to 30 and 40 tons.

A wharf that is not mentioned in the *Year-book* is Tod's. Tod was a speculator who arrived from Sydney in 1839, and acquired land in the neighbourhood of what is now Charlotte Street. Probably the jetty shown in Brees' illustration of Barrett's Hotel, and next to the Commercial Wharf, is Tod's Wharf.

No. 7, Bowler's Wharf, later named after Edward Pearce, who had taken over Bowler's business, was also known as Lyttelton Wharf. This wharf is described as running from Willis Street to Old Customhouse Quay. It ran out from Willis Street virtually parallel to Customhouse Street (or Old Customhouse Street, as it is now called).

No. 9, Waitt's Wharf, was not off Willis Street: it stood out from Customhouse Street. Its present location would be through the vacant section opposite the Public Library, owned, I believe, by Burns, Philp, and Co. This wharf (sometimes called Customhouse Wharf) was never public property. It was a frequently changing property, and with the change of ownership there would usually be a change of name. Of course, in those days Farish Street terminated at Customhouse Street. In 1858 the property was advertised for sale by public auction. The frontage, as advertised, was 147 ft. to Customhouse Street, extending to low-water mark. Part of the frontage faced Farish Street. The wharf, of about 200 ft., extended from a platform on which were erected two iron stores. There was a tramway laid on the wharf, with a crane, nearly new. The price obtained was stated to be £1,500, but apparently the sale fell through, for the property was advertised again in a few weeks. No further sale is recorded until 1860, when Waring Taylor purchased it for £800.

David Robertson's Wharf would probably be known earlier as "Seager's." It, with Greenfield and Stewart's (if there was such a wharf), are of a much later date, and hardly come within the name of "old-timers."

I have found references to Mills' (Lambton Quay, 1846), Tankersley's (Willis Street, 1847), and Turnbull's (Willis Street, 1862).

Queen's Wharf.

Although not agreeing with the *Year-book* that "the history of the port as a shipping-centre really dates from 1862," when the first pile of what is now known as the Queen's Wharf was driven, it may be agreed that 1862 marked a decided move forward. Prior to that date mercantile people could not be expected to be satisfied with the shipping facilities for the larger vessels visiting the port.

Many suggestions were made as to how improvements could be effected. The first move towards something being done took place during the 1852 session of the Legislative Council of New Munster (a nominated body), when the Collector of Customs and the Harbourmaster reported relative to a "deep-water wharf." In their opinion the only suitable site would be near Clay Point, between the Customhouse (then in Customhouse Street) and Pipitea Point; but owing to the shallow water a wharf 800 ft. long would be necessary. The Queen's Wharf is now probably over 800 ft. in length from the original breastwork opposite the Pier Hotel. Two other probable sites were in the Kaiwarra Bight: on the town side of the stream a wharf 60 ft. or 70 ft. long would run out to 21 ft. at low water, spring tides; on the other side of the stream it would be necessary to construct a wharf about 120 ft. long to secure the same advantage; but both of these sites were much exposed to south-easterly gales. It was rather unfortunate that the Province of New Munster was dissolved in 1853, for this body during 1852 had taken definite steps to reclaim land from the harbour, construct a deep-water wharf, and to erect a lighthouse at Pencarrow. Under the Provincial Council of Wellington the town waited five years until another block was reclaimed; waited ten years for the wharf; and waited six years until a modern lighthouse was erected at the heads.

Early in 1857 the Provincial Council appointed a Wharf Committee to consider the "necessity for immediately constructing a wharf in Lambton Harbour that will admit of the largest class of vessel likely to resort to Wellington lying alongside of it; the most suitable spot for its location;

the material of which it had best be constructed; the probable cost; finance; probable income; the cheapest and most efficient system of management should the Council erect and retain the wharf as public property." The Committee took evidence from seven or eight men connected with the local shipping trade, and then decided nothing, but presented the evidence, as it might "be useful when inquiry on the subject shall hereafter be resumed." The answers to the set questions contain many points of interest. The first question read, "Can you state the average delay occasioned by high winds to vessels discharging by lighter?" One man replied, "Two days in three weeks"; two replied, "One day out of six"; while another thought it would be two days out of six. Two who should have had the most practical knowledge, the Collector of Customs and the Harbourmaster, could not say. As to the average time taken to discharge a ship of 500 tons, the general opinion was that it would be one month, although here again the Harbourmaster kept on the careful side: "Depends on state of weather, nature of cargo, the discipline of vessel." It was generally considered that a similar vessel would discharge at a wharf in a week. On the question of site, the general opinion favoured a spot between Clay Point and Kumutoto (Woodward Street). The cost of landing goods by lighter was stated to be about 3s. 6d. per ton, while the charges on the existing wharves amounted to 1s. per ton.

During the same session (1857) another Committee was appointed to inquire as to the advisability of constructing a wharf between Korokoro (Petone) and Lowry Bay. The Committee reported that there were two suitable sites, both near Point Howard. It was also suggested that a tramway to the Wairarapa could be formed by way of the coast. Nothing further was heard of either project.

The deep-water wharf was not mentioned again until 1861, when the site was decided. By this time the land had been reclaimed towards what is now Panama Street. A Provincial Act was passed that year authorizing the Superintendent to construct a deep-water wharf. Complaints were also made that year that Swinburne's Wharf, which was perhaps the most important wharf of the day, was in a bad state and should be repaired or removed.

Tenders were called for on the 21st October, 1861, for the construction of a wharf 35 ft. wide to extend 500 ft. from the sea-wall to a cross-head 50 ft. wide, making a total length of 550 ft. At 300 ft. from the sea-wall tees would extend on both sides, 35 ft. wide and 75 ft. long. Totara piles for the first 250 ft. were to be driven 9 ft. in the ground, for the remainder of the main pier and the inner tees to the depth of 10 ft., and for the cross-head to the depth of 11 ft. Piles were to be sheathed from 1 ft. 6 in. under the surface of the ground to 6 in. above high-water mark, the contractors to provide the timber and labour, the Government providing the necessary sheathing-material, copper, felt, and nails. The piles were to be not less than 12 in. square with all sap-wood removed up to and including the inner tees, while for the remainder and the cross-head 14 in. piles were required. The flooring was to be 6 in. by 3 in. heart of rimu, placed 1 in. apart. Full details of the specification may be found in the *Provincial Gazette*, 26th October, 1861. The depth of water at the end of the wharf was 18 ft., low water. Four tenders were received. That of McLaggan and Thompson (£15,420) was accepted. The other tenders were—Charles Mills, £15,500; Plimmer, Wallace, and Seager, £18,500; James Smith, £18,955. Extras amounted to £884 by the time the wharf

was completed. The first pile was to have been driven on the 18th April, 1862, but owing to a mishap with the pile-driver or the engine, and, after a wait of two hours in a cold south-easter, the ceremony was postponed, taking place on the 28th, when the Superintendent satisfactorily assisted in driving the pile.

The contractors claimed that work was commenced on the 1st April. The totara piles were ordered from the Wairarapa district, but owing to floods the roads and bridges to that district were damaged and heavy goods traffic prohibited, thereby causing delay while arrangements were being made to procure the timber elsewhere. The delay was a serious matter for the contractors, as it landed tham in penalties amounting to £800 for non-completion within the specified time—one year from time of signing the contract (4th December, 1861). In 1863 the contractors applied for a remission of the penalties, but the Petitions Committee decided against them. They petitioned again in 1865, when they were granted £65.

The first interprovincial steamer to berth at the wharf was the "Airedale" (286 tons), which berthed at the inner side of the first tee on the 11th March, 1863. The local steamers "Wonga Wonga" and "Stormbird" had berthed previously. The contractor, John McLaggan, in his evidence on the petition, stated that he had allowed vessels to berth from Christmas, 1862. The first overseas vessel to be berthed was the barque "Queen of the Avon" (460 tons, Captain John Jones), on the 12th August. Wooden rails for a tramway were laid on the wharf in June: this had not been provided for in the contract. The wharf was not level with the Quay, but judging by the wording of the contract was 26 in. higher. No sheds or stores were erected on the wharf. Mr. W. Spinks was appointed wharfinger in June, 1863.

For some years the wharf was known as the "deep-water wharf," or the "Government Wharf," and probably the name "Queen's Wharf" grew from the bonded store, which had been always known as the "Queen's Bond" or "Queen's Warehouse." This was a building erected in 1862–63, on a reclaimed site where Bannatyne and Co.'s offices stand. It was a building, 100 ft. by 46 ft., of three floors, costing £2,700. It was opened 1st May, 1863.

According to a return presented May, 1863, the equipment of the wharf at that time, and the cost, was—

	£	s.	d.	£	s.	d.
Three 2-ton cranes, one 2-ton crane (travelling), and one 5-ton crane	312	10	0			
Six trucks on oak frames	50	0	0			
Freight and charges	51	7	1			
				413	17	1
Eight chains, 22 tons	297	16	6			
Eight mushroom anchors, 23 tons	368	9	0			
Eight buoys, 26 tons	521	4	3			
	1,187	9	9			
Less discount	29	13	9			
	1,157	16	0			
Railway bars, switches, crossings, screws, nails, &c., complete	133	0	0			
Freight and charges	506	12	8			
				1,797	8	8
Charges, including lighterage, exchange, commission, &c. ..	..			179	15	1
				£2,391	0	10

Complaints were soon made about the berthing regulations. Vessels had to moor to buoys placed seaward, and at times might have 200 fathoms of cable out. These moorings naturally interfered with the moorings of other vessels. For a time ship-agents preferred to continue to use the lightering service, while other vessels still used the older wharves. The wharfage charged at this time was 2s. per ton, weight or measurement; horses, 5s. each; sheep, 4s. per score; goods for transhipment, 1s. per ton. No berthage charge was made until a specified time allowance, according to tonnage, had expired. A vessel of, say, 400 tons was allowed up to fifteen days for discharging cargo. There appears to have been no regulation in the matter of loading cargo.

The Clerk of Works from the 1st May to the 23rd December, 1862, was Mr. Henry Bragg; from that time to the completion of the contract Mr. W. H. Hales was in charge. Mr. Bragg was also in charge of the Queen's Bond contract.

In July, 1864, the Council decided to lengthen the southern end of the inner tee and the cross-head, and also to lengthen the main wharf and add another cross-head. The Wharf Committee recommended that the moorings and buoys should be placed not more than 10 to 15 fathoms from the bow of a vessel; that the wharf should be let by public auction; and also that the wharf should be lighted for the safety of passengers, and that the white light at the end of the wharf should be replaced by a red light (the standard for the same to be raised about 8 ft., as there had been complaints that the light had been obscured by the vessel that might be moored at the cross-head). Much technical detail is given in a report on the management of the wharf laid before the Council on the 21st January, 1864. In accordance with the decision to extend the wharf, John Morrison, agent for the Council in London, was requested to invite plans and specifications for the work. Two firms of engineers—Messrs. Kennard Bros., of Westminster, and Crumlin, Wales, and Messrs. Thomson and Browning, London—responded. The scheme of Messrs. Kennard was accepted, with a few alterations suggested by Mr. C. R. Carter, of this town, who was then in England, and who had been asked by the Council to assist in the wharf and patent-slip negotiations.

The contract with Messrs. Kennard, which was dated 25th January, 1865, provided that the wharf should be erected within two years, the contract price to be £31,813, including cost and carriage of plant and material, freight, labour, and all other expenses, but exclusive of Customs duties, the tools and plant required for the construction to be admitted free of duty. The structure was to consist of a framing of wrought-iron plate girders, property bolted together, and resting on twenty-five cast-iron cylinders of 4 ft. diameter each and ninety-five cast-iron screw piles of 1 ft. diameter; the piles and cylinders to be sunk at least 15 ft., and the cylinders to be filled with concrete composed of four parts clean gravel and sand to one part of fresh Roman cement. Two lines of railway and four turntables for the trucks were to be provided and fixed; a 5-ton steam-crane to be provided; also four mooring-screws, with buoys, and 40 ft. of chain to each to be provided and fixed. All of the timber required was to be provided by the Provincial Government to the exact dimensions required, ready for fixing. The timber required for scaffolding, &c., was to be provided by the contractors. The planking was to be 8 in. by 4 in. heart of totara, fixed with their edges ½ in. apart.

Messrs. Thomson and Browning did not make an estimate of the total cost, as they did not propose to erect the wharf. Mr. C. R. Carter, who

was associated with Mr. Morrison in considering the tenders, estimated that it would be about £40,000. Their estimate for material and freight was £20,600.

The extension of the pier was to consist of a jetty 160 ft. long and 35 ft. wide, and a cross-head of 300 ft. long and 50 ft. wide. There was a depth of 26 ft. at low water at end of cross-head.

Messrs. Kennard Bros., who had secured the contract to extend the wharf, sent a staff for the work under Mr. J. R. George, who later became manager of the Wellington Gas Company and the Wellington Patent Slip Company. There were fitters, riveters, divers, carpenters, and labourers. The first detachment arrived in Wellington on the 13th March, 1865, and next day two carpenters commenced work on the erection of a store on the reclaimed land. Arrangements were made for the material to be stored on reclaimed land in Customhouse Quay owned by A. P. Stuart and Co. A. P. Stuart and Co. built a store on the site during the following year, which is still standing, being occupied by the Colonial Carrying Company. The divers effected repairs to the existing wharf. The manager was fortunate enough to secure the contract to rebuild a bridge over the Kaiwarra Stream, thus giving work to some of his men while waiting until required at the wharf. Others worked temporarily at Mills's foundry or at lightering-work.

The first pile of the staging for the main wharf-extension was driven on the 25th October, and the first screw-pile was started on the 5th November. On the 18th December the contractors had secured the contract to extend the two tees of the existing wharf to the southward, the inner tee by 50 ft. and the outer by 100 ft. Work on these extensions (the contract price of which was £2,250) was commenced on the 4th January, 1866. The Provincial Council provided the timber, which had cost £1,550. The first pile of the inner tee was driven on the 6th January, and the work completed on the 14th March. The first pile of the outer tee was driven on the 23rd February, and the work completed on the 1st June. Many divers were engaged on these works; some of the names may be familiar to old watersiders—Goff, Kendall, Hepworth, Poulton, Burton, Hughes, Hawkins, and Lake. The last screw pile of the main extension was driven on the 20th October, 1866. The extensions to the tees were designed by Mr. J. T. Stewart, who had designed the main structure in 1861. New South Wales ironbark sheathed with 18 oz. Muntz metal was used for the piles, which were driven 14 ft. into the ground. Mr. McLeod, recently appointed, was Provincial Engineer of the period. Mr. W. H. Hales was Inspector of Works. The completed work was ready to be handed over to the Government on the 10th January, 1867.

In September one of the Panama steamers ran into the wharf, which was damaged to the extent of £5,000. It was decided to effect repairs in wood at a cost of £2,000, the charge against the company to be £1,000.

In 1868 the Wharf Committee reported that it was advisable that the wharf and warehouse be let; but, before doing so, recommended that the approaches to the wharf should be widened and altered so that carts could take goods direct to or from vessels, and that sheds should be erected for cargo that had to be transhipped. The Committee also recommended improved lighting. W. B. Rhodes was chairman of the Committee. An Act was passed that year empowering the Superintendent to lease the wharf for periods not exceeding three years. Power was given to the Superintndent on the 28th June, 1871, to cause a Bill to be introduced into the General Assembly to authorize him to transfer unsold sections of the reclaimed land

and Queen's Wharf and the Queen's Bond on payment of the amount of £31,000; £19,000 being the amount asked for the wharf and bond. The Bill became law during the same year, under the title "Wellington Reclaimed Land Act."

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The Chemistry of Bush Sickness, or Iron Starvation, in Ruminants.

By B. C. Aston, F.I.C., F.N.Z.Inst.

[Abstract.]

In 1911 the writer published (*Trans. N.Z. Inst.*, vol. 44, p. 288) some preliminary results of his work on bush sickness, a wasting, non-transmissible disease in ruminants, characterized by excessive anaemia, which ultimately proves fatal if the animal be not removed to healthy country. The disease occurs over a large area of country in the thermal district of the North Island. The iron-starvation theory was first published as an hypothesis by the writer in the August, 1912, *Journal of the Department of Agriculture*, p. 124. Since then the work has been continued, the evidence becoming stronger every year, until now it is thought that iron deficiency as a causative agent has been fully proved. (See the series of articles, *Journ. Dept. of Agric.*, April to August, 1924.) The matter is of great economic importance, as not only is the area affected very large (at least a million acres, and probably much more, being affected), but doubts are cast on all pumice lands, the settlement of which is thereby retarded. The soil in the affected area is always derived from an air-borne coarse pumice several feet in depth, resting on rhyolitic country rock. Apparently pumice soils which have been sorted out, compacted, and weathered by water are not bush-sick, since river-terraces and lake-terraces, unless overlain by recent aerial deposits, are free from the disease. Topographical and soil surveys, which are now being carried out, may be expected to throw considerable light on the distribution of bush sickness. The analysis of the blood of sick animals published in 1911 showed a great deficiency of iron, although the grass-ash failed to show any such deficiency. Grass is, however, easily contaminated by soil, and this pumice soil would yield about ten times more iron to the hydrochloric acid than would the grass-ash. Hence, unless

special pains are taken to guard against the entry of this impurity into the samples, unreliable results are obtained. Similarly, pumice soils are entirely abnormal in mechanical composition, the particles consisting of an easily broken solidified froth. This cannot be analysed by the standard methods in use for determining the mechanical composition of ordinary soil. If such methods are used they give unreliable results, the finer fractions tending to become higher in quantity owing to the breaking-down of the particles in the course of preparing the sample for the analysis. The clue afforded by the analysis of blood, suggesting the deficiency of iron, has been followed up in the work undertaken by the Department in the Dominion Laboratory and in the field during the past fourteen years. Areas have been leased and field experiments conducted thereon. Finally, a demonstration farm was purchased at Mamaku, in the heart of the bush-sick country, in an endeavour to learn a practicable method of farming this type of land without periodically changing the stock to healthy country, as is the practice at present. This country is more adapted to cattle than to sheep farming, and, could a practicable remedy be discovered, a great area would be available for dairy-farming.

The chemical part of the work, which has been under the immediate direction of the writer, comprises the analyses of soils, fodder plants, and animal specimens, and these have not shown the presence of any known poison. The absence of poison is, however, indicated by certain facts. Horses may be kept in perfect health for many years upon the same pasture on which ruminants would die in three to nine months, sheep being most and cattle least susceptible. Ruminants, however, when given turnips and hay made from the bush-sick pasture, can be kept healthy while still grazing on the same pasture which as a sole ration would bring on bush sickness. Molasses, bran, and other imported concentrated foodstuffs added in small quantity to the natural ration enable an animal to be kept healthy on the bush-sickness-inducing pasture which, if it contained a poison, would undoubtedly continue to exert its deleterious effects. Again, when an animal at the onset of the sickness has been sent away for a change to healthy country, and after a few months it returns in poor store condition to the pasture upon which it was becoming sick, it fattens or improves greatly in condition. These facts alone, the writer considers, are sufficient to disprove the possibility of poison being present in the natural fodder—cocksfoot-grass and clovers. The author considers that there can be no other explanation of the cause of bush sickness but that which postulates a deficient food-ingredient. It is not to be thought that the organic nutrients are deficient; grasses and clovers grow particularly well on these pumice lands, and provide an ample organic ration. It must therefore be in the mineral or inorganic portion where one must search for the deficient ingredient of the elements necessary to maintain animal life—calcium, phosphorus, potassium, sodium, magnesium, chlorine, iron, and sulphur, named in the relative order in which they occur in the animal's ashes. Iron is the only element about which there can be any doubt as to its presence in sufficient quantity. Phosphorus, although often deficient in the soil, is obviously not low enough to produce nutrition disease in the animal. Phosphorus is stored in the bone of the animal; bush-sick animals show no disease of the bones or other symptoms usually manifested by deficient phosphorus-supply in the diet. Moreover, administration of phosphates to the animal, either medicinally or through the pasture, does not enable them to be kept permanently free from bush sickness. There may be other elements which

are required in very small quantities, such as fluorine and iodine. Nothing is known of the exact need for the former, which must be required only in very small amounts, and the latter has been administered to a sick beast without effecting any improvement. Bush sickness occurs in coastal districts where sulphur is not likely to be wanting. Thus by a process of elimination one naturally arrives at iron as being the deficient element. Of the igneous rocks, the rhyolites, from which the bush-sick soils are derived, are among those rocks which contain least iron. The rhyolitic froth—pumice—which forms the soils, had no doubt been leached before being redistributed by a series of explosions in geological time, long after its formation in the volcano. This redistribution took place, according to Thomas,* not long before the Maori came to New Zealand, which would be probably about a thousand years ago.

The amounts of iron extracted by hydrochloric acid from these pumice soils is of the order of 1 per cent., but the amount extracted in Dyer's 1-per-cent. citric-acid method for "available plant-food" gives about 0·03 to 0·07 per cent. iron, whereas on non-bush-sick pumice soils the amount rises from 0·07 to 0·1 per cent., and on non-pumice soils it may rise to 0·3 per cent. These amounts for iron, compared with the standard amounts required for other constituents—phosphoric acid and potash—in the Dyer method, are high, but the standard for iron may need to be a high one. Another remarkable fact is that when bush-sick pasture is top-dressed with lime the animals become bush-sick sooner than on land which has had no treatment. This may be connected with the well-known fact that chlorosis of plants often occurs on sandy land containing an excess of lime.

It is when one comes to the analyses of fodder plants that the first good evidence of iron deficiency is obtained. Pfeffer (*Physiology of Plants*, p. 428) states that ordinary plants are fully supplied with iron when 0·2 per cent. is present in the ash; but he is no doubt looking at the matter from the plant's point of view, and not from that of the animal which has to subsist on the plant. Analyses of the fodder plants, grasses, and clovers from the bush-sick country show that the iron content of the ash may sink to 0·05 per cent. Although the plant apparently continues to be healthy with this small amount of iron, it may not be sufficient for the animal. The analyses of clovers and grasses of the sick area show that the iron content is very much lower than that of similar plants growing on healthy country. Recent work by Dr. Orr, the Director of the Rowett Institute, Aberdeen, and his associates, has directed attention to the importance of inorganic foods in animal nutrition. An account is given of iron starvation occurring in pigs, when the mother was fed on a fish and vegetable diet containing 1,068 milligrams of food iron per day. It is suggested that the mineral-food requirement of each species of animal may be indicated by the composition of the milk of the species. The faster an animal grows, the more mineral food it requires. A young pig doubles its weight in ten days, but a calf takes forty-seven, a colt sixty, and a human child 180 days. Human milk and mares' milk contain one part, cows' two parts, and pigs' nine parts of iron in equal portions of milk. It is suggested by Kellner that an animal requires two to three times the amount of mineral food that it is able to store up. Sherman lays down the dictum that 12 milligrams of iron per day should be sufficient for an adult human being. Using this data and applying the corrections necessary—*i.e.*, (*a*) for the increased

* A. P. W. Thomas, *Report on the Eruption of Tarawera and Rotomahana, N.Z.*, Wellington, 1888, p. 19.

weight of the species, (*b*) for the increased amount of iron required as shown by the iron content of the milk of the species, (*c*) for the allowance suggested by Kellner for phosphoric acid and lime (two to three times the amount which is present) and assuming that the same holds good for iron, one arrives at the conclusion that if the pasture contains only 0·0025 per cent. of iron, and a cow eats 100 lb. per day, there is good reason to suppose that 1,132 milligrams of iron per day is insufficient for the animal's requirements. A horse, which grows only at one-sixth the rate of a sheep, and the milk of a mare containing only one-ninth of the iron found in sheep's milk, may similarly be shown to be sufficiently supplied with iron from a pasture upon which cows and sheep suffer from iron starvation. Analyses of pasture-plants grown in pots and in the field establish the fact that the iron content of the portion grown in spring and early summer is much lower than that of the portion found in autumn. It is in the spring and early summer that bush sickness is prevalent.

Finally, numerous and long-continued feeding experiments on cattle, and medicinal treatments, have demonstrated conclusively that, although many substances may alleviate or postpone the onset of symptoms of bush sickness, there is only one which will bring an animal back to health when badly affected, the food being unchanged. That substance is a soluble salt of iron, the best of all for the purpose being the double citrate of iron and ammonium, the ferri ammon. cit. of the druggist.

It is to be regretted that the exact iron requirement of ruminants is unknown. The conjectures which are here made as to the requirements are introduced to complete the chain of evidence and to show that iron starvation on green pasture may not be impossible. The main portion of the proof must rest on the evidence supplied by the analysis of the pasture, the soil, and the animal, compared with normal specimens; the medicinal means by which the animal may be restored to health; the manurial means by which the pasture may be rendered capable of growing healthy animals; and, lastly, by the symptoms exhibited by the sick and dead animals to prove that bush sickness is really iron starvation.

There is reason to believe that bush sickness exists in parts of the Dominion other than in those on the pumice lands, but always on a soil of loose sandy nature, or derived from an acidic igneous rock of low iron content. In these cases, owing to the proximity of soil and pasture of higher iron content, and the feeding of supplementary fodder crops in winter, the effects are not likely to be so serious as in those pumice lands where these conditions do not obtain. Further, in at least three widely separated countries outside New Zealand a nutrition disease exactly similar to bush sickness develops, and the writer predicts that it will be found that the cause is in each case the same—viz., iron starvation. These external areas are—(1) In King Island, off the coast of Tasmania, on sandy soil, where the disease is known as "coast disease"; (2) in the Kedong Valley, Nairobi, British East Africa, on a grey volcanic ash, where a wasting disease occurs in cattle; (3) in North Britain, in the Cheviots, and in various parts where a disease in sheep known as "pining," "vinquish," or "daising," occurs on soil derived from porphyritic rock.

PROCEEDINGS.

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OF THE

NEW ZEALAND INSTITUTE.

MINUTES OF THE ANNUAL MEETING OF THE BOARD OF GOVERNORS.

30TH JANUARY, 1923.

THE annual meeting of the Board of Governors of the New Zealand Institute was held in the Dominion Museum Library on Tuesday, 30th January, 1923, at 10 a.m.

Present:—

President, Professor H. B. Kirk (in the chair), and the following Governors:—

Representing the Government—Professor Chas. Chilton, Dr. L. Cockayne, Mr. B. C. Aston (Honorary Secretary).

Representing the Wellington Philosophical Society—Professor C. A. Cotton, Professor E. Marsden.

Representing the Auckland Institute—Professor H. W. Segar and Professor F. P. Worley.

Representing the Philosophical Institute of Canterbury—Dr. F. W. Hilgendorf and Mr. A. M. Wright.

Representing the Otago Institute—Hon. G. M. Thomson, M.L.C.

Representing the Nelson Institute—Dr. R. J. Tillyard.

Representing the Manawatu Philosophical Society—Mr. M. A. Eliott (Hon. Treasurer).

Representing the Wanganui Philosophical Society—Professor P. Marshall.

Representing the Poverty Bay Institute—Ven. Archdeacon H. W. Williams.

The Hon. Secretary called the roll.

Apologies were read from His Excellency the Governor-General, the Hon. Downie Stewart (Minister of Internal Affairs), Dr. J. Allan Thomson (Government representative), and Mr. W. G. Howes (Otago Institute representative).

French Warship.—Professor Marsden reported that he had been asked to convey from Mr. Collins an invitation to visit the French warship, "Jules Michelet," now on a visit to these shores. Ven. Archdeacon Williams and Professor Marsden were appointed a deputation from the Board to wait on the French Admiral and present a copy of the current *Transactions*.

Resolutions of Sympathy.—The President briefly addressed the meeting and asked the meeting to record their sorrow at the passing of those distinguished scientific men connected with New Zealand who had died during the past year—Professor F. D. Brown, Professor Emeritus, Auckland University; Mr. S. Percy Smith, late Surveyor-General of New Zealand; and the two honorary members in Great Britain, Dr. W. S. Bruce and Dr. D. Sharp, F.R.S.

Incorporated Societies' Reports.—Reports were received from the following: Auckland Institute, for year ending 20th February, 1922; Wanganui Philosophical Society, for year ending 31st October, 1922; Philosophical Institute of Canterbury, for year ending 31st October, 1922; Otago Institute, for year ending 30th November, 1922; Wellington Philosophical Society, for year ending 30th September, 1922; Manawatu Philosophical Society, for year ending December, 1922; Nelson Institute, for year ending October, 1922. It was resolved to refer the reports to the Hon. Treasurer to ascertain whether the conditions of incorporation were being complied with.

Annual Report.—The annual report was read and adopted with two minor amendments, as follow:—

Hamilton Memorial Prize: After hearing Mr. Eliott's account of the fund, on the motion of Dr. Tillyard, seconded by Professor Segar, it was resolved, That the amount of the Hamilton Prize for 1923 be £4.

Investment of Hamilton Memorial Fund. On the motion of Mr. Eliott it was resolved, That the funds of the Hamilton Memorial Fund, which were to be invested with the Public Trustee, be transferred to Government war bonds. The motion was seconded by Professor Marshall and carried.

On the motion of Professor Chilton, seconded by Mr. Eliott, it was resolved, That in the Hamilton Memorial Regulations No. 2 all the words after "invest the same" be struck out, and in lieu thereof the words inserted "in any securities proper for trust-moneys."

Report of the Standing Committee of the New Zealand Institute for the Year ending 31st December, 1922.

Meetings.—Eight meetings of the Standing Committee have been held during the year, the attendance being as follows:—Professor H. B. Kirk (President), 7; Dr. L. Cockayne, 7; Professor E. Marsden, 5; Professor C. A. Cotton, 3; Hon. G. M. Thomson, 3; Dr. J. A. Thomson, 1; Mr. A. M. Wright, 1; and Mr. B. C. Aston (Hon. Secretary), 8.

Hector Award.—The award for 1921 was made to Professor C. Coleridge Farr, D.Sc., F.N.Z.Inst., for his researches in physical science, and more particularly for his work in connection with the magnetic survey of New Zealand. On the occasion of the Diamond Jubilee of the Philosophical Institute of Canterbury, 5th April, 1922, Professor Kirk, President of the Institute, who represented the Institute at that commemoration, publicly presented the medal to Professor Farr.

Publications in Hand.—Transactions of the New Zealand Institute, Volume 54: Owing to an extra session of Parliament, with the accompanying pressure of work for the Government Printer during the time usually devoted to the printing of the yearly volume of *Transactions,* Volume 54 has not yet been published.

Dixon's Bulletin of Mosses: On the 21st September the Standing Committee authorized the Hon. Editor to incur the expenditure necessary to publish one plate of illustrations for this bulletin. The proofs have been revised and corrected by the author, resident in England, and the work will shortly be published by the Government Printer.

Exchange List.—The Hofmuseum, Wien, and Natal Museum, Pietermaritzburg, have been added to the exchange list.

Transactions.—Partial sets of the *Transactions* have been presented to the following: Forestry Department, Wellington; Academic Royale des Sciences, Belgique; Universitetsbiblioteket, Uppsala, Sweden; Leland Stanford Jun. University, U.S.A.; Iowa University, U.S.A.

Sales of Publications.—The fact that the Institute has a number of valuable scientific works for sale has been brought more prominently before the book-buying public during the last year by the Hon. Secretary, with the approval of the Standing Committee, with good results.

Annual Reports and Balance-sheets.—The annual reports and balance-sheets of the following incorporated societies have been received, and are now laid on the table:—

Auckland Institute, for year ending 20th February, 1922.
Wanganui Philosophical Society, for year ending 31st October, 1922.
Philosophical Institute of Canterbury, for year ending 31st October, 1922.
Otago Institute, for year ending 30th November, 1922.
Wellington Philosophical Society for year ending 30th September, 1922.
Manawatu Philosophical Society, for year ending 14th December, 1922.
Nelson Institute, for year ending October, 1922.

Fellowship.—On the 20th April the appointment of Robert Laing, Esq., Professor E. Marsden, P. G. Morgan, Esq., and Professor D. M. Y. Sommerville to the Fellowship of the New Zealand Institute was gazetted.

On the 18th May societies were asked to forward nominations for filling the two vacancies for 1923. The societies sent in eleven nominations, and these were forwarded to the Fellows for their selection.

On the 1st September the Hon. Returning Officer, Professor Segar, forwarded the results of the selection, and these were, on the 9th September, communicated to the Governors of the New Zealand Institute.

Hamilton Prize.—At the last annual general meeting a committee was set up to reconsider the rules and regulations of the Hamilton Memorial Prize Fund, and this committee agreed to recommend the following rules:—

1. The funds placed in the hands of the Board by the Wellington Philosophical Society shall be called the "Hamilton Memorial Fund," in memory of the late Augustus Hamilton, Esq. Such funds shall consist of the moneys subscribed and granted for the purpose of the memorial, and all other funds which may be given or granted for the same purpose.

2. The fund shall be vested in the Institute. The Board of Governors of the Institute shall have the control thereof, and shall invest the same in any securities proper for trust-moneys.

3. The memorial shall be a prize to be called the "Hamilton Memorial Prize," the object of which shall be the encouragement of beginners in pure scientific research in New Zealand.

4. The prize shall be awarded at intervals of not less than three years by the Governors assembled in annual meeting, but in no case shall an award be made unless in the opinion of the Governors some contribution deserving the honour has been made. The first award shall be made at the annual meeting of the Governors in 1923.

5. The prize shall be awarded for original pure scientific research-work, carried out in New Zealand or in the islands of the South Pacific Ocean, which has been published within the five years preceding the 1st day of July prior to the annual meeting at which the award is made. Such publication may consist of one or more papers, and shall include the first investigation published by the author. No candidate shall be eligible for the prize who prior to such period of five years has published the result of any scientific investigation.

6. The prize shall consist of money. Until the principal of the fund amounts to £100, one-half of the interest shall be added annually to the principal, and the other half shall be applied in payment of the prize. So soon as the said principal amounts to £100 the whole of the interest thereon shall be applied in payment of the prize, in each case after the payment of all expenses necessarily incurred by the Governors in the investment and administration of the said fund and award of the said prize.

7. A candidate for the prize shall send to the Hon. Secretary of the New Zealand Institute on or before the 30th day of June preceding the date of the annual meeting at which the award is to be made an intimation of his candidature, together with at least two copies of each publication on which his application is based.

8. Whenever possible the prize shall be presented in some public manner.

The above rules were submitted to the Wellington Philosophical Society and to the Standing Committee of the New Zealand Institute, and were signed by Dr. C. E. Adams and Professor H. B. Kirk, Presidents of the Wellington Philosophical Society and the New Zealand Institute respectively.

On the 30th March the Standing Committee resolved to inform the Wellington Philosophical Society that the Institute was prepared to undertake the administration of the Hamilton Memorial Fund, to invest it and expend it in the manner agreed upon.

On the 8th May the Wellington Philosophical Society wrote intimating that the Council of their society had finally approved of the regulations, and that the fund would be transferred to the New Zealand Institute. On the 10th May the societies were circularized and asked to make known the rules to their members.

Two candidates applied for the Hamilton Prize, and the award is to be decided at the annual meeting.

The amount of the Hamilton Fund paid over to the New Zealand Institute on the 21st October was £48 7s. 11d., and this has now been invested in Government war bonds.

It will be seen from the foregoing rules that Rule No. 2 requires amending. The fund has now been invested not with the Public Trustee but in war bonds, thereby earning about 1¾ per cent. more interest. A resolution of the Board of Governors at the annual meeting is necessary to put the matter in order,* and the consent of the Wellington Philosophical Society obtained to this course.

Pan-Pacific Congress.—At the last annual meeting it was resolved that every endeavour be made to hold the Pan-Pacific Congress in New Zealand in 1923. After due consideration it was found impossible to take any steps to extend an invitation to the Congress to meet in New Zealand, and the Australian representative was accordingly notified to this effect.

Kapiti Island.—At a meeting of the Standing Committee held on 30th March the President, Professor Kirk, reported that the Board of Control had visited the island, and that he and Mr. McClure, Commissioner of Crown Lands of the Wellington District, had been deputed to draw up a report. The President presented his report, which is as follows :—

"*Kapiti Island—Report on Visit of Advisory Committee.*

"In accordance with a resolution passed at the meeting of the committee on the 6th February, Messrs. G. H. M. McClure, W. H. Field, M.P., E. Phillips Turner, and Professor H. B. Kirk visited the island, arriving at noon on Saturday, 18th March, and leaving at 3 p.m. on Sunday, 19th March.

"After a fairly comprehensive inspectiom of the island it was evident that sheep were fairly numerous in all the open portions, and to some extent were present in some of the bush-clad portions. At the northern end, where the Crown lands abut on the Native-owned portion of the island, and along the eastern coast and around Rangatira, the sheep were nearly all shorn ones; but in the Taepiro clearing, and from there to the southern end, they were mostly wild sheep.

"In all, some forty-five goats were seen, twenty of which were on the eastern coast of the island between the Maraetakaroro Stream and Wharekohu Bay, where there is practically no bush, and where tauhinu and manuka scrub are now growing on what was formerly open land in danthonia-grass. A few were seen in the bush. It is not possible to make any useful estimate of the numbers on the island from the observations of so short a visit; nor does that greatly matter, seeing that all are to be killed. As bearing, however, on the efficiency of the caretaker, it should be stated that many dead goats, or remains of dead goats, were seen. These were in very varied condition as to freshness, from goats killed within a week or so to skeletons and other remains of goats killed a year or more back. They were to be found in practically all parts visited, and often at a considerable distance from the track taken by most of the party—in other words, in positions such that the observation of them by members of the party could have nothing to do with the route taken, in so far as that route was suggested by the caretaker. We are satisfied that the caretaker has not neglected this difficult part of his work.

"On the damage done by goats and sheep there is no need that we should enlarge. The most ominous indication of this is that, except in the denser bush, there is never more than partial regeneration, and often there is degeneration that is obviously progressive.

"Many dead trees were seen, especially ratas; but in nearly all cases these trees were of greater height than the surrounding bush, and it is probable that their death is due to the very wind-swept condition of the island; but it may be due to bacterial or fungoid disease. It is certainly not due to the presence of stock. No trace could be found of injury to the bark, and many of them are still surrounded by bush too dense

* See motion carried at annual meeting of 30th January, 1923—*Investment of Hamilton Memorial Fund*—p. 728 of this volume.

for stock to penetrate. These trees have been dead for many years. It will be remembered that Dr. Cockayne described them in his report presented to Parliament in 1907.

"In suitable places birds were numerous, and the volume of song great and varied. Makomako, tui, and parakeets were abundant; very many whiteheads were seen; fantails, wrens, robins, and tits were fairly numerous; wekas were seen and heard everywhere. Few pigeons were seen. This is not strange, seeing that the pigeon, like the kaka, is rather a visitor to the island than a permanent resident. Even fifty years ago, although pigeons might be very numerous on the island for a month or two in each year, they passed most of their time on the mainland. Among the parakeets were several of the large Antipodes Islands species, liberated on Kapiti some years ago.

"The committee is satisfied that the caretaker is doing his work well, and that when the fence is erected and sheep are removed the island will become a bird-sanctuary in the proper sense of the term. The completion of the work of exterminating goats cannot be achieved in a few weeks, seeing how many places are accessible only with great difficulty, but we think that within a year goats should be very hard to find, even if the last has not by then been killed.

"We are of opinion that the caretaker should, with the consent of the owners, visit the small islands from time to time, and should leave no chance of rabbits remaining on them."

Professor Kirk reported on the 28th December that the fence dividing the Native lands from the rest of the island has been erected by the Government, and the Natives have been called upon to remove all their sheep from the Crown Lands. The Government has proceeded actively with the killing of goats and opossums.

Destruction of Native Birds.—At a meeting of the Standing Committee held on the 21st December it was resolved to ask Internal Affairs Department if any permission had been granted to persons to kill native birds in order to supply the forthcoming Exhibition in London with exhibits. On the 29th December the Hon. the Minister replied that the matter will receive due consideration, and promised to communicate again with the Institute at a later date.

Mount Hauhangatahi and the Tongariro National Park.—The President, after conferring with Mr. Field, M.P., arranged that the Standing Committee should meet delegates from the various bodies interested and discuss the best means to stop the destruction of the forest now in progress at Hauhangatahi. On the 17th February the Standing Committee met delegates from the Forestry Department, Forestry League, Tararua Tramping Club, and Wellington Philosophical Society. Officers of the State Forest Service were present. Mr. Field, who had drawn attention to the fact that the forest was being milled, addressed the meeting. He stated that he and Mr. Phillips Turner had camped at Mangitipopo hut and found a mill established at Erua by the Prisons Department authorities; and cutting was also seen in the area denominated a national military training-ground. He referred to a fire which had been said to have been started by a prisoner. Mr. Field reminded the meeting of a promise of the late Dr. McNab that the boundaries of the park should be extended to include the Hauhangatahi Bush.

After some discussion it was arranged that representatives from the New Zealand Institute, Forestry League, Manawatu Philosophical Society, Auckland Institute, and Wanganui Philosophical Society should accompany Captain MacIntosh Ellis to the park on a visit of inspection.

During the meeting it was resolved to urge the following:—

(1.) That the suggested boundary of 1920 be made the boundary of the National Park, and that milling be definitely forbidden within the area.

(2.) That certain areas of silver-pine be permanently reserved.

(3.) That a Board of Control of the Tongariro National Park be set up.

(4.) That the Board of Control contain representatives from the Te Heuheu family, the New Zealand Institute, the Auckland Institute, the State Forest Service, the Tourist Department, and one representative from the Alpine Club of New Zealand, the Ski-ing Club, and the Tararua Tramping Club.

It was also resolved that a deputation should wait upon the Prime Minister.

On the 5th May Captain Ellis visited the park, accompanied by Major R. A. Wilson (who represented the New Zealand Institute), Mr. Field, M.P., Mr. H. A. Goudie, and Mr. S. R. Crowley.

A second meeting of the Standing Committee and the delegates was held on the 23rd June to consider the report of the visit to the area as presented by Mr. Field and Major Wilson. A map was produced by the Forestry Department setting forth the extensions which it was prepared to concede. It was resolved to accept these

boundaries, and, further, that an area on the Kaimanawa Mountains and Mount Umukarikari ought to be set aside. These boundaries did not include all that the delegates wished for, but the State Forest Service was prepared to declare the remainder permanent State forest, to be milled only under the strictest conditions of selective logging. It was also decided to ask the co-operation of the Forestry Department, with a view to doing everything possible to preserve the amenities of the park, especially along the Ohakune track. The following resolutions were passed:—

(1.) That the Tongariro Sports Club be added to the list of bodies that should send a joint representative to the Board of Control.

(2.) That the Government be asked for an endowment sufficient to provide for the maintenance of the park.

(3.) That Mr. Field be asked to organize a deputation to the Minister of Defence with regard to the Military Reserve.

(4.) That a Bill be promoted extending the boundaries as agreed to.

On the 14th September a deputation consisting of the Hon. G. M. Thomson, Professor H. B. Kirk, Dr. L. Cockayne, Professor E. Marsden, and Mr. B. C. Aston (representing the New Zealand Institute), Mr. W. H. Field, M.P., and Mr. W. A. Veitch, M.P., together with representatives from the Wanganui and Manawatu Societies, Forestry League, Forestry Department, Tararua Tramping Club, Sports Protection League, and Ski-ing Club, waited upon the Prime Minister. Professor Kirk placed before him the desire of the various bodies represented to have the park boundaries extended to include Hauhangatahi and the military training-ground area. Also, in addition, they asked that portion of the Hautu Block (Kaimanawa Mountains) be included. Without this portion the proposals meant an addition of about 105,750 acres. It was asked that the forest areas between the new boundaries and the railway-line should be made premanent forests by Act of Parliament and not merely by Order in Council.

Mr. Massey said the proposals met with his approval. He thought that the Board of Control should be set up, and he hoped practical men would be selected with the necessary Government representation.

During the session the Tongariro National Park Bill was introduced and became law. It provided for many of the proposals which had been suggested, including extension of the boundaries of the park and a Board of Control, to consist of the Mayors of Wellington and Auckland, the paramount chief of the Maori people responsible for the gift, the Under-Secretary of Lands, the General Manager of the Tourist Department, the Secretary of the State Forest Service, the President of the New Zealand Institute, and four members nominated by the Government.

Great Barrier Reef Committee.—On the 21st September the Standing Committee appointed Mr. W. R. B. Oliver to represent it as a corresponding member on the Great Barrier Reef Committee, set up by the Royal Geographical Society of New South Wales. On the 19th January Mr. Oliver reported that since the inauguration of this committee it has met four times, and the following business has been transacted: Appointment of officers and representatives; appointment of sub-committees—Coastal, Physiography, Oceanography, Geology, Zoology, Botany.

Reports from these sub-committees, giving suggestions for carrying out investigations on the Barrier Reef, were presented at the fourth meeting of the committee, held 15th December, 1922. The principal suggestions embodied in the reports are—(*a*) the establishment of a marine biological station; (*b*) a topographical and oceanic survey of the reef; (*c*) a census of the entire fauna and flora of the reef; (*d*) an ecological survey of both animals and plant life; (*e*) a report on the animals and plants of economic importance; (*f*) an investigation into the general geological structure of the reef; (*g*) a study of the mode of formation of atolls, and the origin and characteristics of coral reefs in general; (*h*) the compilation of a bibliography.

Library Removal.—At the last annual meeting the Board, having before it the strongly expressed approval of the Board of Science and Art and the approval of the Wellington Philosophical Society in the matter of the proposed improvement of the Institute's library, authorized the Standing Committee to continue negotiations with Victoria College Council in regard to the housing of the library, provided the finances permitted. At a meeting of the Standing Committee held on the 4th February it was resolved, That if on inquiry it be found that the cost of transport and shelving in connection with the proposed removal of the library to Victoria College can be kept within £50 the Institute will ask the Victoria College Council to accept the custody of the books as a provisional measure.

On the 17th February the President reported that the Under-Secretary of Internal Affairs had consented to assist in the removal of the library to Victoria College by the

loan of the Department's motor-van, and in permitting the removal of the shelving, except that which was on the south wall in the library.

A committee consisting of two members of the New Zealand Institute and two members of the Wellington Philosophical Society was appointed to determine the ownership of the books at present in the library.

The agreement drawn up by Mr. Levi, Chairman of the Victoria College Council, was submitted to the Standing Committee on the 21st September, and it was resolved to insert a clause safeguarding the present privileges of members to take out books, to the effect that members of the New Zealand Institute should be placed on the same footing with regard to the books of the Institute deposited in the Victoria College Library as the College staff are now with regard to the College Library.

On the 14th November a commencement was made with the removal of the books. Three men were engaged from the Public Works Department, and Internal Affairs lent its motor-van for the purpose. With the assistance of the Institute's officers, the work took over a week to complete, and the books which are now in Victoria College will be available to members as soon as they are arranged on the shelves.

Carter Library.—The Under-Secretary of Internal Affairs having intimated on the 11th December that the Hon. the Minister had approved of the conditions laid down by the annual meeting in January last, the keys of the Carter Library book-cases, with a list of the contained volumes, were handed to Mr. Andersen on the 28th December. Mr. Andersen and his staff removed the volumes to the Alexander Turnbull Library, and the cases are being transferred by the Public Works Department, the cost of transit being borne by the Internal Affairs Department.

Travelling-expenses.—On the 17th February the Standing Committee resolved to approach the incorporated societies to ascertain if each society would in future agree to bear the cost of the travelling-expenses of its representatives attending the annual meeting of the Board. The following societies replied: Auckland Institute was not in favour of the proposal; Manawatu Philosophical Society asked that expenses be pooled and the cost to each society be apportioned according to the number of its delegates; Philosophical Institute of Canterbury asked that the expenses be pooled; Wellington Philosophical Society agreed to pay expenses of its delegates. It was decided to refer the matter to the annual meeting for discussion.

Incorporated Societies.—In accordance with a resolution of the last annual meeting the reports and balance-sheets of the incorporated societies were submitted to the Hon. Treasurer to determine whether the regulations were being complied with. (See also Presidential Address, vol. 50, p. 342.) His report has since come to hand, and at a meeting of the Standing Committee held on 21st September it was decided to postpone consideration until the annual meeting.

Publications Fund.—In order to assist in publication expenses the Standing Committee, at a meeting held 17th February, 1922, decided to issue a circular to every member of the Institute, appealing for a contribution to the funds of the Institute. The circular was issued in March, and resulted in a sum of £160 15s. 4d. As, however, it was promised in the circular to publish an acknowledgment of all donations, and by November only about one-fifth of the members had contributed any donation, it was thought advisable to issue a second reminder, in order that those desirous of contributing might have an opportunity before the last date for accepting matter for the annual volume in which it was contemplated publishing the list of donations. This was issued on the 1st November, with the result that a total of £188 4s. 5d. has been received towards the fund. Mr. W. G. Howes donated to this fund the amount of his travelling-expenses at the annual meeting.

On the 20th June it was resolved to vote £100 of the above amount to the cost of illustrations in Volume 54.

Carter Bequest.—At the last annual meeting a committee was set up to prepare plans and estimates on the lines of the majority report for submission to the Board of Governors at its next annual meeting, provided that legal power could be obtained for using the money as indicated in the majority report.

On the 9th June Professor Sommerville, convener of the above committee, wrote requesting the Institute to obtain legal opinion with regard to the utilization of the residue of the Carter Bequest for the purpose of erecting an observatory in accordance with the recommendations of the majority report. The Standing Committee decided to consult Messrs. Bell, Gully, Mackenzie, and O'Leary on the matter, and these

solicitors forwarded their opinion on the 6th December, 1922. This firm gave a lengthy report, quoting similar cases and the judgments therein, and in conclusion stated, "The fund bequeathed by Carter has already been accumulated for twenty-six years, and the period at which it could be properly applied in fulfilment of the testator's wishes *in toto* is still extremely remote. We have taken time to consider the question submitted for our opinion, and have concluded that the indicated intention to accumulate is void, and that the Board is not bound to continue the accumulation. The Board, however, is not entitled to divert the fund without directions from the Court, and in our opinion the Court should be asked to approve the scheme outlined in the resolution passed by the Governors on 30th January, 1908."

The resolution referred to above is as follows: "That the Board will agree to the expenditure of the Carter Bequest in the purchase, erection, &c., of an astronomical telescope and accessories, as proposed by the deputation from Victoria College, and allow the same to be under the control of the governing body of the College, on the following conditions: (1) That the observatory and other necessary buildings be erected out of other funds; (2) that a Professor of Astronomy and staff be appointed and maintained by Victoria College out of funds other than the Carter Bequest; (3) that the Board be advised that the expenditure is legal."

Fireblight.—At the last annual meeting a resolution was passed urging the necessity, in view of the southward spread of fireblight, of defining special orchard areas within which the elimination of hawthorn should be carried out on lines approved by the Minister of Agriculture. This resolution was conveyed to the Hon. the Minister of Agriculture, who replied on the 21st April, 1922, that further legislation for the control of fireblight was then receiving the careful consideration of his Department, and he assured the Institute that its views would be carefully considered in this regard.

Hutton Research Grant.—Miss Mestayer reported on the 21st September as follows: "I regret that owing to ill health I have been unable to use the balance of £5, which I still hold. However, I hope that next year I shall be able to use it."

Resolutions of Standing Committee not otherwise mentioned in the Report.

1. On the 4th February it was resolved, That the writers of all papers sent in to the Hon. Editor for publication in Volume 54 of the *Transactions* be written to by the Hon. Editor and informed of the decisions of the Board with regard to the part cost of future illustrated publications to be borne by the writer, and also to be informed of the method of calculating the cost of illustrations.

2. On the 4th February it was resolved, That, in view of the enhanced income of the Hector Fund, the amount awarded annually be reconsidered at the annual meeting.

3. On the 17th February it was resolved to postpone in the meantime the issue of the circular to the new exchanges proposed by the sub-committee last year.

4. On the 21st September it was resolved, That modified circular be sent to the proposed exchanges, but no sample volume to be sent. Further list of proposed universities to be referred to the annual meeting.

5. On the 30th March it was resolved, That the President should represent the Institute at the celebrations of the Diamond Jubilee of the Philosophical Institute of Canterbury.

6. On the 30th March it was resolved, That when the next volume is distributed, to notify members of the omission of four pages of plates facing p. 124 from some copies of Volume 53, in order that where possible the mistake might be rectified.

7. On the 30th March it was resolved, That Volume 54 should contain an account of the life of Sir James Hector, and a portrait.

8. On the 20th June it was resolved to allocate the cost of obtaining Mr. Blair's opinion *re* the investment of the trust funds to the different funds.

9. On the 21st September it was resolved to inform the Public Trustee that there was no present prospect of carrying out the provision in the will of C. R. Carter regarding the erection of a building, and to ascertain from him what the position was concerning the income from the £50 allotted for the purpose of building a room to house the Carter books.

On the 21st December it was resolved to nominate Professor Kirk, Dr. L. Cockayne, and Dr. C. A. Cotton as delegates from the New Zealand Institute to the General Council of the Australasian Association for the Advancement of Science.

On the 21st December it was resolved to bring up at the annual meeting the question of the quorum of the Standing Committee meetings.

Library Matters.—The draft of the agreement with Victoria College as to the housing of the Institute's library in Victoria College was adopted. Two letters from Dr. Allan Thomson, dated 27th January, were read. The President, Professor Kirk, supplied the following report:—

REMOVAL OF LIBRARY.

The advantages contemplated in the housing of the Institute's library at Victoria University College were—comparative immunity from danger of fire and more stringent custody, better supervision, and better arrangement than it was possible to ensure at the Dominion Museum in its present circumstances. In the hope of securing these advantages the Board gave instructions for the continuance of negotiations with the Professorial Board, and, through it, with the College Council. These negotiations resulted in an agreement one of whose features is that it allows very free access to the books on the part of members of the Institute.

It was hoped that the Wellington Philosophical Society would decide that its library should go with that of the Institute; but the society decided against this course, although, in common with other affiliated societies, it was in favour of the removal of the Institute's books. Seeing that books of the Institute, of the Philosophical Society, and of the Dominion Museum were shelved together, and that the stamps of the three institutions had often been used at haphazard, with the result that one series sometimes bore all three stamps, it became necessary to determine the ownership of books. With this object a joint committee was set up. On this committee the Institute was represented by Mr. Aston and Dr. Cotton; the Philosophical Society by Mr. Hamilton and Mr. Oliver, both members of the Museum staff, and representing its interests also. For a short time, during the absence of these two members, they were relieved by Mr. Morgan and Mr. Phillipps. The task of the joint committee was a very difficult one, involving a considerable amount of search in old records, old letter-books, and other documents. There still remains a number of books in the galvanized-iron building in Sydney Street, and in the Museum itself, of which the ownership is not yet settled, and it is possible that among those that have been removed there are some of which the ownership should be reviewed.

The removal took place in November and December. The Board is much indebted to Mr. Hislop, Under-Secretary for Internal Affairs, for the use of the Department's lorries, and for permission to remove the shelving, except that on the south wall, that being required for the books of the Museum. Acting on the representations of the Philosophical Society, it was decided to leave half the shelving on the east wall for the society's books.

The books recognized as the property of the Institute are now at Victoria College, and I am giving what time I can to sorting them. This is a very long job, and one in which there is room for two or three volunteers. The help of the Assistant Secretary has not yet been available, as her time has been fully occupied in the work of the annual meeting. In any case, much of the preliminary work is too heavy for a woman. Every effort will be made to have the library in order as soon as possible.

It has been arranged that, where serial publications already in the College library are incomplete, but are more nearly complete than in the Institute's library, they shall, as far as possible, be completed from the Institute's books used for that purpose, bearing a stamp "Lent by the New Zealand Institute"; and that where the Institute's serials are the more complete they shall, in like manner, be completed as far as possible from the College shelves. There will remain a considerable number of duplicate volumes belonging to the Institute. These the Institute cannot part with, but it can accede to the request made by the Director of the Dominion Museum, and to a similar request, if made, by the Director of the Geological Survey Department, to house the books with them, under the necessary precaution as to safe and efficient custody.

The Carter Library, which is the joint property of the Institute and the Government, has been removed to the Alexander Turnbull Library, and the Librarian, Mr. Johannes Andersen, has kindly agreed to give Mr. Elsdon Best, who is just now engaged on important research, very full access to the books.

I conclude this report with a hearty recognition of the immense amount of work done by Mr. Aston in connection with the removal.

6th February, 1923. H. B. KIRK.

Position of Incorporated Societies.—The Hon. Treasurer read his reports on the incorporated societies, dated 11th April and 8th May, 1922. The Poverty Bay and the Wellington Societies were the only ones which had

not complied with the conditions of incorporation. The President then moved the following resolutions, which were seconded by Mr. M. A. Eliott, and carried :—

(1.) That in the assessment of the said proportion of one-third or one-sixth, as the case may be, any incorporated society shall be entitled to include any special levy made by the Institute to defray or to help to defray the cost of the *Transactions*.

(2.) That Regulation 4 read as follows: "In the case of any society incorporated as aforesaid which shall in any one year have failed to expend the proportion of revenue specified in Regulation No. 3 aforesaid in manner provided, the Institute shall, unless it is satisfied that special circumstances have been shown to justify a temporary delay, declare the said society to be disincorporated, and that society shall from henceforth cease to be incorporated with the Institute."

Bird-life Destruction.—Correspondence with the Hon. the Minister of Internal Affairs, dated 22nd and 29th December, 1922, was read. It was resolved to approach the Minister again on this matter.

Hector Prize.—On the motion of Mr. Eliott, seconded by Dr. Chilton, it was resolved, That the amount of the next Hector Prize be £45.

Hon. Treasurer's Reports: Trust Funds Management.—On the motion of Mr. Eliott, seconded by Professor Segar, it was resolved, That half of 1 per cent. of the capital invested on account of the Carter, Hector, Hutton, and Hamilton Trust Funds be contributed by these funds towards the cost of administration.

HON. TREASURER'S REPORT.

The statements of receipts and expenditure and assets and liabilities show that the funds of the Institute are in a much better position than they were at this time last year. This is mainly due to the fact that £1,750 has been received from the Government (£750 balance due for 1921 and £1,000 due for 1922), as against only £250 received during the previous year, and that no debit appears in the accounts for Volume 54, *Transactions*. Voluntary contributions to the Publication Fund also helped to swell the revenue by £188 4s. 5d.; on the other hand, the sale of publications was £46 less, and incorporated societies' levy £64 less, than in the previous year.

The increased revenue enabled us to pay the Government Printer a considerable portion of the amount due to him. On the 31st December, 1921, the amount owing was £1,740 11s. 8d.; this has now been reduced to £304 10s., £1,450 having been paid off during the year.

The work in connection with the handling of the various trust funds controlled by the Institute takes up a good deal of the time of the Assistant Secretary, and it appears to me that it would be right and proper that a portion of the salary paid her should be contributed by the various funds. If, say, half of 1 per cent. of the capital invested was so paid it would produce about £35 per annum, which, I consider, would be a fair and reasonable charge to make. It would mean that the net interest earned by the several funds would be reduced from, say, 6 per cent. to 5½ per cent.

During the year, at my suggestion, the Assistant Secretary has opened a new set of books under the double-entry system. This will enable the financial position of the Institute to be promptly and accurately ascertained at any time, and will also prevent mistakes remaining undiscovered, as well as greatly assisting the auditor and myself in checking over the balance-sheet.

Trust Accounts.

As a result of the policy of the Board in deciding to invest the Carter Bequest, Hector, Hutton, and Hamilton Memorial Funds in New Zealand Government inscribed stock (Discharged Soldiers Settlement Loan), these trust funds are earning considerably more revenue, and are in a very healthy condition.

Carter Bequest.—This started the year with a debit balance in the revenue account of £21 10s. 9d. The sum of £301 5s. was earned in interest during the twelve months, £271 3s. 5d. of which was reinvested in further inscribed stock, and the Revenue

Account now shows a credit balance of £8 10s. 10d. The capital invested as on the 31st December, 1921, was £4,883 18s. 5d. in 5½ per cent. inscribed stock, due 15th January, 1933, purchased at £91 5s., the market price to-day being £100 10s. The total capital now stands at £5,155 1s. 10d. The rate of interest earned during the year was just on 6 per cent. (6·02).

Hector Memorial Fund.—The revenue account shows that £67 5s. was earned in interest during the year, £48 18s. 4d. of which was reinvested in inscribed stock. The present debit balance of £30 2s. 7d. will be more than liquidated by the six months' interest due this month. The capital invested as on the 31st December, 1921, was £1,135 19s. 9d., to which must be added £48 18s. 4d., making the total capital £1,184 18s. 1d.

Hutton Memorial Fund.—The Revenue Account shows that £56 15s. was earned, which, with £13 14s. 2d., balance brought forward from previous year, makes a total of £70 9s. 2d., of which £68 6s. 7d. was reinvested. The Capital Account, including this £68 6s. 7d., now stands at £1,014 5s. 1d.

Hamilton Memorial Fund.—The capital sum of £48 7s. 11d. was received during the year, which was invested in war bonds.

M. A. Eliott, Hon. Treasurer.

New Zealand Institute.—Statement of Receipts and Expenditure for Year ending 31st December, 1922.

Receipts.

	£	s.	d.
Balance as at 31st December, 1921	2,072	9	8
Statutory grant, balance, 1921 and 1922	1,750	0	0
Publications sold	50	14	5
Incorporated societies' levy	39	12	3
Government grants for research	265	0	0
Grants refunded by grantees	15	0	0
Interest, Post Office Savings-bank	71	0	3
Travelling-expenses refunded to Endowment Fund	4	15	2
Interest on Carter Bequest	301	5	0
Interest on Hector Memorial Fund	67	5	0
Interest on Hutton Memorial Fund	56	15	0
Hamilton Memorial Fund, from Wellington Philosophical Society	48	7	11
Interest on Hamilton Fund war bonds	1	2	6
Contributions to Publication Fund	188	4	5
Refund law-costs from Trust Accounts	3	3	0
Interest reinvested inscribed stock—			
Carter Bequest	124	0	11
Hector Memorial Fund	15	18	4
Hutton Memorial Fund	40	16	7
	£5,115	10	5

Expenditure.

	£	s.	d.
Government Printer	1,450	0	0
Travelling-expenses, Governors	60	5	10
Petty cash, postages, &c.	23	16	2
Petty cash, balance in hand	6	3	10
Salaries	231	5	0
Insurance premium	5	0	0
Bank commission and cheque-book	1	0	0
Research grants, as per list	473	13	7
Hector Prize for 1921 (Mr. R. Speight)	45	0	0
Interest invested inscribed stock—			
Hector Memorial Fund	48	18	4
Carter Bequest	271	3	5
Hutton Memorial Fund	68	6	7
Trust funds transferred to separate accounts	207	9	2
Hamilton Memorial Fund invested war bonds	48	11	10
Postage on circulars, Publication Fund	6	12	2
Balance, as under	2,168	4	6
	£5,115	10	5

	£ s. d.
Balance in—	
Bank of New Zealand	424 5 10
Post Office Savings-bank	1,743 18 8
	£2,168 4 6

Made up as follows :—	*Dr.* £ s. d.	*Cr.* £ s. d.
Endowment Fund	..	193 12 7
Government research grants	..	1,256 12 6
Library Fund	..	245 15 0
Government Printer	..	304 10 9
Revenue Account balances	..	10 16 1
Hector Memorial Fund overdrawn ..	30 19 9	..
Hamilton Memorial Fund overdrawn ..	0 3 11	..
Profit on year's working	..	233 1 5
Sundry debtors	14 0 0	..
Cash in Post Office Savings-bank Trust Accounts	24 16 4	..
Petty cash in hand	6 3 10	..
	£76 3 10	£2,244 8 4
		76 3 10
		£2,168 4 6

M. A. Eliott, Hon. Treasurer.

Examined and found correct.—J. H. Fowler, Deputy Controller and Auditor-General.

New Zealand Institute.—Statement of Assets and Liabilities as at 31st December, 1922.

Liabilities.	£ s. d.
Carter Bequest Capital Account	5,155 1 10
Hector Memorial Capital Account	1,184 18 1
Hutton Memorial Capital Account	1,014 5 10
Hamilton Memorial Capital Account	48 7 11
Government research grants—Balance	1,256 12 6
Endowment Fund	193 12 7
Library Fund	245 15 0
Government Printer	304 10 9
Carter Bequest Revenue Account	8 6 6
Hutton Memorial Revenue Account	1 7 1
Hamilton Memorial Revenue Account	1 2 6
Balance of assets over liabilities	233 1 5
	£9,647 2 0

Assets.	£ s. d.
Inscribed stock, Discharged Soldiers Settlement Loan, £7,550 ..	6,965 17 5
Post Office inscribed stock, £400 at 5 per cent.	388 8 4
Government war bonds, £50 at 4½ per cent.	48 11 10
Cash at Bank of New Zealand	424 5 10
Cash at Post Office Savings-bank	1,743 18 8
Cash at Post Office Savings-bank—Trust Accounts	24 16 4
Petty cash in hand	6 3 10
Sundry debtors	14 0 0
Hector Memorial Fund overdrawn	30 19 9
	£9,647 2 0

NEW ZEALAND INSTITUTE.—GOVERNMENT RESEARCH GRANTS FOR YEAR ENDING 31ST DECEMBER, 1922.

1922.			Dr. £ s. d.	Cr. £ s. d.
Jan. 1.	By	Balance in hand	..	1,450 6 1
Mar. 2.		Grant (Treasury)	..	25 0 0
June 29.		Grant (Treasury)	..	100 0 0
Oct. 6.		Grant (Treasury)	..	15 0 0
Nov. 3.		Grant (Treasury)	..	25 0 0
Dec. 19.		Grant (refunded)	..	15 0 0
Dec. 24.		Grant (Treasury)	..	100 0 0
Feb. 20.	To	Mr. D. D. Milligan	25 0 0	..
April 11.		Professor Marsden	60 5 7	..
May 6.		Professor Malcolm	15 0 0	..
May 11.		Miss Curtis	78 17 0	..
June 27.		Professor Farr	1 16 0	..
July 3.		Professor Marsden	50 0 0	..
July 14.		Professor Farr	2 15 0	..
July 24.		Professor Malcolm	25 0 0	..
Aug. 6.		Professor Marsden	50 0 0	..
Sept. 30.		Professor Burbidge	100 0 0	..
Oct. 25.		Canterbury Philosophical Institute ..	15 0 0	..
Nov. 7.		Professor Malcolm	25 0 0	.
Nov. 8.		Mr. D. D. Milligan	25 0 0	..
		Balance	1,256 12 6	..
			£1,730 6 1	£1,730 6 1

NEW ZEALAND INSTITUTE TRUST ACCOUNTS.

Carter Bequest Revenue Account for Year ending 31st December, 1922.

	£ s. d.		£ s. d.
To Amount overdrawn ..	21 10 9	By Interest to 15th January, 1922	147 2 6
Interest invested ..	271 3 5	Interest on 15th July, 1922	147 2 6
Law-costs	1 1 0	Interest on interest invested	7 0 0
Balance	8 6 6	Interest in Post Office Savings-bank	0 16 8
	£302 1 8		£302 1 8
		By Balance	£8 6 6

Hector Memorial Fund Revenue Account for Year ending 31st December, 1922.

	£ s. d.		£ s. d.
To Amount overdrawn ..	3 9 3	By Interest to 15th January, 1922	33 0 0
Mr. R. Speight—Prize ..	45 0 0	Interest to 15th July, 1922	33 0 0
Interest invested ..	48 18 4	Interest on interest invested	1 5 0
Law-costs	1 1 0	Interest in Post Office Savings-bank	0 3 10
		Balance	30 19 9
	£98 8 7		£98 8 7
To Balance	£30 19 9		

Hutton Memorial Fund Revenue Account for Year ending 31st December, 1922.

	£	s.	d.		£	s.	d.
To Interest invested	68	6	7	By Balance, 1st January, 1922	13	14	2
Law-costs	1	1	0	Interest to 15th January, 1922	27	10	0
Balance	1	7	1	Interest to 15th July, 1922	27	10	0
				Interest on interest invested	1	15	0
				Interest in Post Office Savings-bank	0	5	6
	£70	14	8		£70	14	8
				By Balance	£1	7	1

Hamilton Memorial Fund Revenue Account for Year ending 31st December, 1922.

	£	s.	d.		£	s.	d.
To War bonds	48	11	10	By Amount from Wellington Philosophical Society	48	7	11
Balance	0	18	7	Interest to 15th December, 1922	1	2	6
	£49	10	5		£49	10	5
				By Balance	£0	18	7

Carter Bequest.—Public Trust Office Statement for Period from 30th June, 1922, to 31st December, 1922.

RESIDUARY CAPITAL ACCOUNT.

Receipts.	£	s.	d.
Balance	50	0	0

RESIDUARY INCOME ACCOUNT.

Receipts.	£	s.	d.	*Disbursements.*	£	s.	d.
Public Trust Office—Interest to 31st December, 1922, at 3 per cent.	2	5	0	Beneficiary's Account: Governors of New Zealand Institute—Cash	2	5	0
	£2	5	0		£2	5	0

Assets.	£	s.	d.	*Liability.*	£	s.	d.
Cash as Capital Account ..	50	0	0	Donation—Colonial Museum (payable when compliance with conditions in will is effected)	50	0	0
	£50	0	0		£50	0	0

Financial Statements of the Institute, as follows—statement of receipts and expenditure, statement of assets and liabilities, trust accounts—having been duly audited by the Auditor-General, were adopted.

Travelling-expenses.—On the motion of Mr. Wright, seconded by Professor Marsden, it was resolved, That the actual travelling-expenses of members of the Board be paid for this meeting. On the motion of Mr. Eliott, it was resolved, That the opinion of the incorporated societies be taken on the question of pooling the expenses of members of the Board and each society paying its share. An estimate of the cost to be se each society under this proposal.

Publication Committee's Report.—The report of this committee was received and adopted with the deletion of one paragraph. Mr. J. C. Andersen attended by request of the Board and gave information regarding the progress of the printing of Volume 54 and other matters. Professor Marsden moved, and Dr. Cockayne seconded, That Volume 55 be not published until 1924. The motion was lost. Dr. Cockayne, seconded by Professor Marsden, proposed that what would be Volume 54 be now published in two volumes as Volumes 54 and 55. The motion was lost.

Report of Publication Committee.

It is to be hoped that Volume 54 (for 1922) may be issued towards the end of January. There are several reasons for the delay—financial difficulties, an early session of Parliament, and an extra number of papers, many of great length. Seventy-eight papers by fifty-five authors were submitted, forty-eight by thirty-eight authors being accepted for publication, as against sixty-seven papers by forty-eight authors submitted last year, of which fifty-three by thirty-seven authors were accepted. The committee had much difficulty, firstly in reducing the number of papers, secondly in reducing the length of many of those accepted. Reduction was made first by the authors themselves, and in some cases a further reduction was made by the committee.

In spite of the fact that authors were required to pay for their illustrations, the papers are more fully illustrated than usual. The committee observes this with pleasure, whilst at the same time it feels that the penalizing of enthusiastic workers is neither equitable nor desirable. A paper good enough for acceptance should be accepted as a whole; and the committee would suggest that papers might be limited to say thirty pages, except for extraordinary reasons, and illustrations limited to four plates and four pages of text-figures, or their equivalent, the author being put to no expense except for extra copies of reprints. If, however, any author wishes to publish a longer paper or to illustrate more fully, he should be at liberty to do so, subject, of course, to the usual censorship, provided he is willing to pay for the additional space and illustrations.

So many new species are dealt with in the present volume that it has been felt that its value would be enhanced by a full index, and this has been supplied; and if such index can be continued from year to year the necessary task of indexing the whole set of the *Transactions* will be a task of known magnitude, and not one whose magnitude grows with the years.

For the next volume only some thirty papers are in hand—mostly short, a few of moderate length—and it will probably be possible to limit that volume to two hundred pages or less.

For the Committee. JOHANNES C. ANDERSEN, Hon. Editor.

Research Grant Committee's Report.—This was received. On the motion of Mr. Aston, seconded by Dr. Hilgendorf, it was resolved, That a property list of books, apparatus, &c., bought out of the Research Grant Fund be compiled, and circulated to members of the Board and printed in the *Transactions.*

On the motion of Mr. Aston, seconded by Dr. Cockayne, it was resolved that the Research Grant Committee be asked to make a comprehensive report on the state of all researches undertaken with the Institute's financial aid during the last ten years. It was resolved that those applicants in the Research Grant Report who asked for further grants be informed that their requests are held over until the Research Grant Committee can give some idea of the state of this fund.

Report of the Research Grant Committee for the Year ending 31st December, 1922.

Dr. C. E. Adams, who in 1919 was granted £55, through the Wellington Philosophical Society, for astronomical instruments, reported on the 5th January, 1923, that a prism d been secured in England at a cost of £33 11s. 11d. He states that before the prism used it must be suitably mounted on the telescope with a camera, &c. The To Balan d cost of mounting is £12 and the camera £8, and he makes application for an £20 for this purpose.

Mr. G. Brittin, who in 1919 was granted £100, through the Philosophical Institute of Canterbury, for a research on fruit-diseases, reported on 27th December that comparative investigation of experimental plots has proved the spraying calendar as advocated by him to be of great benefit in controlling brown-rot of the peach and other stone-fruits. He forwarded specimens to Miss Curtis, of the Cawthron Institute, who is investigating the fungus that causes the buds to drop and the laterals to die back. The microtome ordered came to hand this year, but, as Mr. Brittin had already made other arrangements, Professor Kirk took it over. Mr. Brittin delivered a lecture before the Motueka Fruitgrowers' Association this season, and a condensed report of it was published in the *Nelson Mail* and in the November issue of the *New Zealand Fruitgrower*. Credit balance of grant, £94 10s. 6d.

Professor Burbidge, who in 1921 was granted £100, through the Auckland Institute, for a research on the intensity of long-wave signals from Europe, reported on the 28th November that the apparatus required for this research had just arrived from England, and was being assembled to start the records. As the apparatus purchased took the whole of the grant, Professor Burbidge makes application for a further £25 to cover working-expenses.

Dr. Kathleen Curtis, who in 1920 was granted £100, through the Nelson Institute, for research in parasitic mycology, reported on the 16th December that work during the past year had been confined to black-spot of the apple and pear. No results that might be utilized from the practical point of view have been obtained, and it is therefore proposed that next year this work will be discontinued, and that on brown-rot of stone-fruits resumed. The whole of the grant has been expended in books.

Professor W. P. Evans, who in 1919 was granted a further £200, through the Philosophical Institute of Canterbury, for an investigation of New Zealand brown coals, reported on the 15th December that experimental work had been carried out by himself and three assistants, as follows: (*a*) Ultimate analyses of and distribution of sulphur in twenty-nine coals from the South Island; (*b*) leaching experiments on three typical coals, with special reference to the change in ash; (*c*) examination of a coal-resin from Central Otago, &c. The furnace ordered in 1921 had come to hand, and had been fitted by itself in case of its being required elsewhere. No results had been published. A general account of the work done is being presented to the Australian Association for the Advancement of Science, at Wellington, and arrangements are being made for the publication of various portions in scientific journals. Credit balance of grant, £125 6s. 2d.

Professor C. Coleridge Farr, who in 1919 was granted £100, and later a further £90, through the Philosophical Institute of Canterbury, for a research on the porosity of porcelain, reported on the 5th January that a paper embodying the results of this research was published in the October, 1922, issue of the *Journal of the American Institute of Electrical Engineers* in the 41st volume, on page 711. (This publication is temporarily available to members of the Board of Governors at this meeting.) That the work has been of interest outside of New Zealand as well as of importance within it is shown by an extract from a letter received by Mr. Birks from Mr. F. W. H. Wheadon, of the Adelaide Electric Supply Company; and, referring to an arrangement for testing insulators for Adelaide, Mr. Wheadon says, "I am sure there are a number of us here who are so vitally interested in this matter that we would be very glad if such an arrangement could be made"; and Mr. Parry has also written to Mr. Birks from London saying (*inter alia*), "The results are very important, and, what is more, are very much more conclusive than any that have hitherto been published."

The paper which has been published is by Farr and Philpott, and is in substance very much the same as was submitted in type to the Board of Governors last year.

An expenditure of £134 8s. 6d. has been incurred, which leaves a credit balance of £55 11s. 6d.; but it is thought by the authors of the paper that the work has now become of such a practical nature and so routine in practice that any further expenditure upon it should be borne by the Public Works Department, and not come upon the Research Grant Fund of the New Zealand Institute, which is essentially for investigations of an uncertain and experimental nature. It is considered that the work has now progressed beyond that stage, and become of a commercial character.

Mr. George Gray, who in 1920 was granted £50, through the Philosophical Institute of Canterbury, for an investigation on the waters of Canterbury, reported on the 28th November that owing to ill health no work has been done during the past year; and, as there seemed to be little probability of its being resumed in the future, the grant of £50, of which no part has been expended, is reluctantly surrendered.

Mr. T. L. Lancaster, to whom, with Mr. Cornes, in 1919, was granted £50, through the Auckland Institute, for a research on the growth of kauri, reported on the 12th December that during the year little progress had been made. Mr. Cornes had accepted

a permanent position in Christchurch, and, as it was a difficult matter to carry on the research single-handed, Mr. Lancaster reluctantly relinquished the whole of the grant.

Professor Malcolm, who in 1919 was granted £250, and in 1920 a further £175, through the Otago Institute, for a research on the food value of New Zealand fish, reported on the 24th December that work was resumed in August, with the help of Mr. T. B. Hamilton, M.A., B.Sc. It is hoped to publish Part 3 of the series of papers on food values in the next volume of the *Transactions*. He had hoped to commence experiments on the vitamines in New Zealand fish-oils, and spent considerable time and some money on preparatory work when, unfortunately, a fire occurred in the Department, which destroyed the tame rats he had brought from England for this purpose. Credit balance of grant is £85.

Professor Malcolm, who in 1918 was granted £30, through the Otago Institute, for a research on the pharmacology of New Zealand plants, reported on the 24th December that the work was practically at the same stage as in his last report. If the Board is agreeable he would like to have the time for the final report again extended, as he has a considerable amount of data collected for a paper, but he wished to confirm certain experiments before publishing, and the other research had taken all his spare time this year. Credit balance in hand, £14.

Professor Farr, who in 1921 was granted £75 (of which £60 was last year transferred to his porcelain grant), through the Philosophical Institute of Canterbury, for investigations into the properties of gas-free sulphur, reported on the 5th January that the work of this research had been going on during the year, although no expenditure had been necessary. Some expense would be incurred, however, as it had become necessary to design some glassware which is too complicated to be made at the Laboratory. Credit balance of grant, £15.

Professor Marsden, who in 1922 was given a special grant of £100 for an investigation on the Taupo earthquakes, reported on the 14th October that the money had been spent on expenses of three journeys to Taupo, and on constructing and installing three instruments at Wairakei, later at Taupo. An assistant to take observations was also paid for four weeks. Professor Marsden has several hundred earthquake records nearly all worked up as regards amplitudes, periods, and time of various phases of quakes. He has made records of subsidences north of Taupo causing the earthquakes, and made arrangements to follow the movements and quakes by installing seismographs at Taupo and arranging tide-gauges to be placed round the lake.

Professor Marsden, who in 1919 was granted £125, through the Wellington Philosophical Society, for a research on the effect of α particles on matter, reported on the 16th October that a preliminary account of the research had been accepted for publication by the *Journal of Atmospheric Electricity and Terrestrial Magnetism*. A fuller account is in progress, and will be submitted when certain comparative measurements have been made at Apia. Credit balance of grant, £69 19s. 8d.

Mr. D. D. Milligan, who in 1920 was granted £50, through the Nelson Institute, for a research on New Zealand orthoptera, reported on the 14th November that at the end of February he started his investigations in the North Auckland Province. He purposes this summer joining a camping-party from the Auckland University College to visit the Waipoua State Forest, when he trusts to have better collecting. Credit balance in grantee's hand, £16 10s.

Mr. W. G. Morrison, who in 1919, was granted £100, through the Philosophical Institute of Canterbury, for a research on natural afforestation, reported on the 3rd January that during the past year he had been unable to carry on any research work. He finds that it will be impossible to carry on further work on the lines hitherto followed, owing to the increase of duties in connection with his work in the State Forest Service, and he feels he cannot trespass further on the grant, the balance of which, £26 19s. 7d., will be returned to the Institute in due course. He would like, however, to obtain the assent of the Institute to the use of the camera for the next twelve months, with the option of taking it over at the end of that period at the price paid for it. Balance of grant, £56 19s. 7d.

Mr. R. Speight, who in 1919 was granted £225, through the Philosophical Institute of Canterbury, for a geological examination of the Malvern Hills, reported on the 17th November that the examination of the area had been continued as occasion offered. Special attention had been paid to the south-west part of the area, and it was hoped by the end of 1923 a definite report on the geology would be available. The investigations carried on revealed no results of special commercial value, except the possibility of the existence of a fair amount of coal in the Glenroy area. The new mine opened a little while ago near White Cliffs turned out much better than expected, and there is now a considerable amount of coal in sight, and the promise of the existence of a valuable area of brown coal in a workable seam or seams within reasonable distance

from rail. If working facilities could be improved the output of the mine could be substantially increased. Credit balance of grant, £189 4s. 4d.

Mr. L. Symes, convener of the Artesian Wells Committee, which was granted £100, through the Philosophical Institute of Canterbury, reported on the 28th December that owing to a variety of circumstances work had been in abeyance. Dr. Hilgendorf had now returned, however, and observations would be resumed almost at once. The committee requests that the balance of the grant, £57 14s. 2d., should be available for the continuation of the work.

Hon. G. M. and Mr. G. Stuart Thomson, who in 1919 were granted £50, through the Otago Institute, for a research on the economic value of whale-feed, sent in a paper on the 15th December bearing on this subject. The paper states that in summer large shoals of a bright-red shrimp are met with on the sea-coast of New Zealand. This animal is popularly known as "whale-feed." The paper describes its life-history, occurrence, and commercial value. In an average season such enormous quantities of these shrimps occur that at times they are thrown up on beaches in millions. Masses of them several inches deep are thus heaped on the shore, and when collected and carted away on to the soil form a good manure.

An attempt was made to ascertain—(1) The quantity of oil present in these shrimps; (2) the nitrogen content; (3) the percentage of phosphoric acid. From the analysis it is clear that it would never pay to treat whale-feed as a commercial source of oil and manure, except occasionally, perhaps, in the immediate neighbourhood of a suitably installed plant for dealing with fish-offal. The capture of the fresh material would require the use of finer-meshed nets than are usually employed by any New Zealand fishermen. The handling of the fresh material and the subsequent treatment of it—drying, oil extraction, and grinding—would probably cost, at present prices of labour, &c., not less than £2 per ton, and this would leave a margin of only £1 8s. 7d. per ton. It has further to be remembered that such a plant would only be available for treatment of whale-feed when there was a scarcity of fish, a contingency not likely to happen, for when whale-feed are abundant fish are usually abundant too. The authors point out that already the production of nitrogenous manure in the frozen-meat industry of the Dominion is greater than the demand. From all these considerations they are of the opinion that there is very little commercial value in whale-feed under present conditions.

The whole of the grant has been used. (A chemical balance is now available for other research workers from this grant.)

Mr. A. M. Wright, who in 1921 was granted £75, through the Philosophical Institute of Canterbury, for an investigation into the vitamine content of commercial meat-products, reported on the 12th December that the investigation had been carried out during the past year with a view of determining the reliability of the growth of yeast in pure culture as a method of estimating the vitamine content of foodstuffs. The method employs yeast instead of animals as the test-organism in the determination of Vitamine B. A number of modifications have been the subject of experimental study, and one gives promise of yielding satisfactory results. No publication of results has yet been made; the earlier (1921) results have been the subject of various lectures and demonstrations, popular accounts of which have appeared in various newspapers. It is requested that the balance of the grant, £25, be available for a further year.

Attention should be directed to the fact that where a large credit balance is shown in any grant, most of it is in the hands of the Institute, and is bearing interest in the Post Office Savings-bank.

Regulation Committee's Report.—This was received, amended, and adopted. It was resolved, on the motion of Dr. Chilton, seconded by Professor Marsden, That the report be suitably edited by the same committee, and printed.

REPORT OF THE REGULATIONS COMMITTEE.

Committee: Mr. J. C. Andersen, Dr. J. A. Thomson, and Mr. B. C. Aston.

The Institute books have been searched, and the following motions or resolutions are grouped for convenience of reference under the various heads. In the references the following contractions are used: M.B., minute-book; A.M., annual meeting; Proc., Proceedings of the Institute.

Authority is sought for the adoption of those portions which are italicized.

For the Committee.

16th January, 1923. B. C. ASTON.

Regulations to be gazetted.

BOARD OF GOVERNORS.

1. Members of the Board of Governors shall not hold any paid office under the Board. (1905 M.B., p. 21.)

2. Travelling-expenses of members of the Board of Governors shall be paid. (M.B., p. 18, 2nd A.M.)

PUBLICATIONS.

5. (*g*.) Ten separate copies of papers shall be printed for the Institute in addition to the copies supplied to the author. (1909 A.M.)

GENERAL REGULATIONS.

The President shall be *ex officio* a member of all committees.

The Hon. Editor shall be convener of the Publication Committee. (1905 M.B., p. 21.)

The seal of the old Institute *bearing the date of establishment as 1867* shall be adopted as the seal of the New Zealand Institute *reconstituted by the New Zealand Institute Act, 1903, and continued by the New Zealand Institute Act, 1908.* (1910, p. 92, Proc. iv.)

An abstract of all business transacted at each meeting of the Standing Committee shall be prepared and communicated to all members of the Board after each meeting. (1910 A.M.)

The quorum of the Standing Committee meetings shall be four. (1922 A.M.)

ENDOWMENT FUND.

A fund to be called an Endowment Fund shall be set up, the interest *on which for any year* may be spent for purposes of the Institute, but the capital may not be spent. (1918 A.M.)

All interest accruing from moneys deposited in the *Institute's General Account* in the Post Office Savings-bank shall be credited to the Endowment Fund, *unless otherwise allocated by the Board at the annual meeting at which the amount of the annual interest is reported.* (1920 and 1923 A.M.)

Trust-moneys namely, the Carter, Hutton, Hector, and Hamilton Funds—shall, when deposited in the Post Office Savings-bank, be placed in separate accounts for each trust. (1923 A.M.)

REGULATIONS FOR ADMINISTERING THE RESEARCH GRANT.

8. Grants shall be given preferentially to investigations which appear to have (1) an economic bearing; purely scientific investigations to be by no means excluded. When the research is one that leads to a direct economic advance the Government shall reserve to itself the right of patenting the discovery and of rewarding the discoverer; but it is to be understood that grants from the research-grant vote are not in the nature of a reward or a prize, but for out-of-pocket expenses incurred by the research worker, including salary or endowment of assistant, but not salary for the grantee himself. Plants, books, apparatus, chemicals, &c., purchased for applicants are to remain the property of the Institute, and eventually to form a loan collection of apparatus in the manner *now* practised by the Royal Society of London.

First method of initiating researches: Applications shall be invited for grants in aid of research to be specified by applicants.

Second method of initiating researches: The Governors of the Institute shall suggest from time to time subjects the investigation of which is desirable, and to ask capable investigators to undertake such researches, the Institute paying for apparatus, material, and working expenses, including assistance. (1917 A.M.)

2. All applications for grants shall come through some incorporated society. (1922 A.M., p. 807, vol. 54.)

3. In the case of a refusal to recommend a grant, the Standing Committee shall not give any reasons for its refusal unless such reason is stated in the minutes. (1921 A.M., p. 491, vol. 53.)

FELLOWSHIP REGULATIONS.

26. Add—

(*a*.) The consent of the candidate must be obtained in writing.

The information regarding each candidate shall be condensed to one foolscap sheet of typewritten matter. (1922 A.M., p. 800, vol. 54.)

When a candidate is proposed by more than one society it shall be sufficient to circulate to voters the information supplied by one society.

FELLOWSHIP ELECTION.

Subsection E shall be rescinded, and the following inserted :—

The voting-paper for the election of Fellows shall be in the following form :—

Names of Candidates, in Alphabetical Order.

....
....
....
....

There are vacancies to be filled. Place a cross in the column marked X against the name of each candidate for whom you wish to vote.

The vote will be invalid if -

(*a*.) More than the required number is voted for on the paper;
(*b*.) The voter signs the voting-paper;
(*c*.) The voting-paper is not returned on the date announced. (1923 A.M.)

HAMILTON MEMORIAL FUND REGULATIONS.

As amended at the annual meeting, 1923. (See p. 2, Report of Standing Committee for year 1922.)

CARTER BEQUEST.

That the fund known as the Carter Bequest, consisting of the principal originally placed by the Board of Governors in the hands of the Public Trustee, together with the interest accrued thereon, be withdrawn from the Public Trustee and reinvested in such securities as provided for by legislation covering trust-moneys, power to arrange details and to act being given to the Hon. Secretary and the Hon. Treasurer acting conjointly. (1922 M.B., p. 205.)

HECTOR MEMORIAL FUND.

That the fund known as the Hector Memorial Fund, consisting of the principal originally placed by the Board of Governors in the hands of the Public Trustee, together with the interest accrued thereon, be withdrawn from the Public Trustee and reinvested in such securities as provided for by legislation covering trust-moneys, power to arrange details and to act being given to the Hon. Secretary and the Hon. Treasurer acting conjointly. (1922 M.B., p. 205.)

HUTTON MEMORIAL FUND.

That the fund known as the Hutton Memorial Fund, consisting of the principal originally placed by the Board of Governors in the hands of the Public Trustee, together with the interest accrued thereon, be withdrawn from the Public Trustee and reinvested in such securities as provided for by legislation covering trust-moneys, power to arrange details and to act being given to the Hon. Secretary and the Hon. Treasurer acting conjointly. (1922 M.B., p. 205.)

That until the Hutton Memorial reaches the sum of £1,000 not less than 1 per cent. on the capital invested be added each year to the principal. (1908 M.B., p. 93.)

HONORARY MEMBERS.

Vacancies in the list of honorary members shall be announced at each annual meeting of the Board of Governors, and such announcement be communicated as early as possible to each incorporated society, and each such society shall, on or before the 1st December, nominate one person for each vacancy as honorary member, and the election shall take place at the next annual meeting of the Board of Governors. (1919 A.M., p. 471, vol. 51.)

Resolutions to be printed.

PUBLICATIONS.

1. That the *Transactions* be printed at the Government Printing Office. That, with the object of expediting the publication of volumes of the *Transactions*, papers received after the 31st December of any year be not included in the volume for that year; that papers be sent to the Editor as soon as possible after they have been read before the various societies. That the Publication Committee be authorized to proceed with the publication at once, and that authors' copies be dated and issued to authors as soon as printed. (19/1/05 M.B., p. 12.)

2. That publication of papers in local newspapers will militate against publication in the *Proceedings* of the Institute. The Publication Committee be given full discretion in the publishing of abstracts of papers published in full elsewhere. (1905 M.B., p. 18.)

3. That there is no reason for including in the *Transactions* meteorological returns published elsewhere. (1906 M.B., p. 79).

4. That the Publication Committee do not publish seismological returns in the *Transactions*. (1908 M.B., p. 79.)

5. That Volume 41 be the first of a new series, and consist of two separately published parts: Part 1 to contain the scientific papers, plates, and index. (1908 M.B., p. 82.)

Part 2 to contain:—

(*a*.) The annual address of the President of the Institute.
(*b*.) Proceedings of the societies and presidential addresses.
(*c*.) Short abstracts of papers not printed in full.
(*d*.) Summaries of scientific papers appearing in other publications on matters of interest to New Zealand science, prepared by specialists, and lists of the scientific publications issued by the Department of Agriculture, Chemistry, &c., during the year.
(*e*.) Instruction to writers of papers.
(*f*.) Report of the annual meeting of the institute, with balance-sheets.
(*g*.) The New Zealand Institute Act.
(*h*.) Regulations of the Hutton Memorial Fund; annual report of the same; report of the Hector Memorial Fund; report of the Carter Bequest.
(*i*.) Obituary notices of honorary members and members of local societies. (1908 M.B., p. 82.)

6. That in future the volumes of the *Transactions* be published in royal 8vo size (1908, vol. 41, p. 447.)

7. That extra copies of the *Transactions*, not to exceed 5 per cent of the number due to the society, be sent to the Secretary of that society if he applies for them. (1909, p. 98, Proc.)

8. That authors be supplied with twenty-five copies of their papers free, and that if the Editor be notified of the author's requirements at the time the paper is sent in further copies be supplied at cost price. (1909, p. 99, Proc. 4, and 1922 A.M.)

9. That authors be allowed to contribute towards the cost of publishing such illustrations as are approved by the Hon. Editor. (1912, vol. 25, p. 417.)

10. That the Standing Committee be authorized to dispose of the stock of *Transactions* for those years in which the number is in excess of 200 by gift to suitable institutions, or by sale at reduced terms. (1915, vol. 48, p. 528.)

11. That the Standing Committee be authorized to increase the exchange list. (1915, vol. 48, p. 529.)

12. That a set of publications as complete as possible be presented to the University of Louvain (1915, p. 528, vol. 48.)

13. That the Standing Committee make arrangements with the Government Printer to distribute the copies of the *Transactions*. (1916, vol. 49., p. 534.)

14. That a set of bulletins published each year be forwarded to all societies on the exchange list. (1916, vol. 49, p. 540.)

15. That the matter of publishing future bulletins be left in the hands of the Publication and Standing Committees to deal with at their discretion. (1917, vol. 50, p. 332.)

16. That the issue of separate printed copies of the minutes of the annual meeting of the Board of Governors be discontinued, but that copies of an abstract of minutes be sent to each incorporated society as soon as possible. (1920, vol. 53, p. 497.)

17. That in future the cost of making the blocks for plates and text-figures be charged to the authors. (1922 M.B., p. 217.)

CONCERNING THE EDITOR.

1. That it be an instruction to the Hon. Editor of the *Transactions* to follow the rules of botanical nomenclature agreed upon at the Vienna Congress of 1905 in the printing of the *Transactions* (1908 M.B., p. 83.)

2. That all matters in connection with the printing of the *Transactions* be managed by the Hon. Editor direct with the Government Printer. (1909 M.B., p. 153.)

3. That the Publication Committee be authorized to arrange for the publication of the volumes of *Transactions* and for the printing on the title-page of each paper the date of receipt by the Editor and the date of issue by the Printer. (1916, vol. 49, p. 540.)

4. That descriptive notice of the publications of the Institute be given on the outside back cover of the *Transactions*. (1912, p. 99.)

5. That it be a recommendation to the Publication Committee to alter the "Memorandum for Authors of Papers" (see p. 11, vol. 49 or 50) by the deletion of the words "Secretary of the society before which it was read," and the insertion therefor of the words "Editor of the *Transactions*." (1918, vol. 51, p. 471.)

6. That it be a recommendation to authors of papers to adhere as nearly as possible to the metric system in the statement of any weights or measures. (1918, vol. 51, p. 471.)

7. That the Standing Committee be instructed to take steps to index Vols. 41–51 when funds permit. (1918, vol. 51, p. 465.)

8. That the Publication Committee be directed to insert a notice in the *Transactions* stating the privileges of members in relation to the libraries of the Institute and of the incorporated societies. (1915, vol. 48, p. 528.)

9. That it be an instruction to the Publication Committee to edit the *Transactions* more severely in future, particularly with regard to the length of papers; that the papers in hand be refereed not only from the point of view of suitableness but from the point of view of length. (1922 M.B., p. 217.)

CONCERNING THE HON. SECRETARY.

1. That the Standing Committee should prepare for the annual meeting in each year a list of the resolutions of importance passed by it during the year, including those passed by the Board of Governors at the last annual meeting. (1909, Proc. 4, p. 97.)

2. That the Hon. Secretary be instructed to furnish each member of the Board with a copy of the report of the Standing Committee and the business to be submitted at the meeting one week previous to the meeting of the Board of Governors. (1912, A.M.)

FINANCIAL.

That the Minister of Internal Affairs be asked to obtain a grant to enable the Board of Governors to distribute spare volumes of *Transactions* to public libraries, secondary and technical schools of the Dominion, branches of the Teachers' Institute: and to suitably bind and forward the set of *Transactions* to the University of Louvain. (1915, vol. 48, p. 529.)

TRUST FUNDS MANAGEMENT.

That half of 1 per cent. of the capital invested on account of the Carter, Hector, Hutton, and Hamilton Trust Funds be contributed by these funds towards the cost of administration. (1923 A.M.; rescinded 1924 A.M.)

CARTER BEQUEST.

1. That the New Zealand Institute will view with satisfaction vigorous steps in the direction of developing the Carter Fund to the point at which the wishes of the benefactor can be carried into effect. (1920, vol. 20, p. 482.)

2. That permission be given to the Standing Committee to house the Carter Library in the Turnbull Library if they could make suitable arrangements to do so. (1921 M.B., p. 171.)

3. Conditions of transfer of library. (See 1922 M.B., p. 205.)

HAMILTON MEMORIAL FUND.

1. That the Standing Committee be authorized to co-operate with the Wellington Philosophical Society in arranging the terms on which the balance of the Hamilton Memorial Fund should be handed over in trust to the New Zealand Institute (1917, vol. 50, p. 333.)

2. That applications be made forthwith to the Wellington Philosophical Society to hand over the moneys of the Hamilton Memorial Fund for administration by the New Zealand Institute in conformity with the rules drawn up. (1920 M.B., p. 170.)

CONCERNING THE PROPERTY OF THE INSTITUTE.

1. That the Government be urged to provide a suitable building in which to house the valuable library and records of the Institute, the destruction of which would be an irreparable loss to the country. (1916, vol. 49, p. 541.)

2. That application be made to the Hon. the Minister of Internal Affairs for a grant, as soon as circumstances permit, sufficient to provide for binding the large number of unbound publications now in the library of the Institute. (1918 A.M., vol. 50, p. 332.)

LONDON AGENCY.

That the London agency be transferred to W. Wesley and Son. (1909 M.B., p. 163.)

INCORPORATED SOCIETIES.

1. That it is desirable that all branches of the Institute should end their financial year on or before 31st December, so that their annual reports and balance-sheets may be placed before the annual meeting of the Board. (1909, p. 97.)

2. That for every copy of volume 49, *Trans. New Zealand Institute*, received by the incorporated societies a contribution of 2s. 6d. shall be made during the current year by such society. (1916, vol. 49, p. 539.)

3. That for every copy of volume 54 of the *Transactions* received by the incorporated societies a contribution of 5s. towards the cost of printing be made during the current year by such society (1922 M.B., p. 217.)

4. That the affiliated societies be asked to collect the amounts due for authors' reprints and forward same to the Hon. Secretary, New Zealand Institute. (1913, vol. 46, p. 359.)

CONCERNING VARIOUS COMMITTEES.

That all committees shall, in a formal report to the annual meeting, furnish an account of their year's work (1908, vol. 41, p. 449.)

That the duties of the Observatory Committee shall be—

(1.) To take into consideration all matters concerning the foundation, development, and maintenance of all observatories in New Zealand and Samoa devoted to astronomy or any branch of earth physics or vulcanology.

(2.) That the Committee communicate its recommendations from time to time to the Standing Committee, who shall, if they deem necessary, take action thereon. (1921 M.B., p. 170.)

That the Standing Committee meet at regular stated times, the first Tuesday in every month at 2 p.m. to be the ordinary dates of meeting. All members of the Board to be informed of any change in the regular date of meeting. (1923 A.M.)

CONCERNING SCIENCE AND INDUSTRY.

That this Institute believes that one of the first and most important steps in the direction of encouraging the application of science to industry is the formation of a scientific and technological library in the Dominion, and urges the Government to take immediate steps to provide such a library. That the New Zealand Institute, as the body which for fifty years has persistently encouraged the carrying-out of scientific researches, offers the Government its services in the interests of national efficiency; and that a deputation be appointed to wait upon the Acting-Premier to present to him a report as to the relations of science and industry and to urge the necessity of definite action. (1916, vol. 49, p. 541.)

LIFE MEMBERSHIP EXCHANGE.

That incorporated societies be recommended to adopt the following ruling: When a life member of an incorporated society takes up his residence in another district his name be retained on the roll of the original society, from which he should receive the *Transactions*, and the society of the district to which he transfers should grant him full membership privileges. (1923 A.M.)

HONORARY MEMBERSHIP.

That the qualifications for honorary membership as supplied by the nominators of each candidate be forwarded to members of the Board by the 15th December of each year. (1923 A.M.)

Election of Fellows.—The election for the two Fellowships was then taken, and the Ven. Archdeacon H. W. Williams and Mr. J. C. Andersen were duly elected.

Hector Award, 1923.—The President read the recommendation of the Committee of Award—Professor Chilton (convener), Professor Haswell, and Mr. T. F. Cheeseman—forwarding the name or Mr. G. V. Hudson. On the motion of the President, it was unanimously resolved to adopt the committee's recommendation and confer the award on Mr. G. V. Hudson.

Canterbury College, Christchurch, 29th January, 1923.

The President, New Zealand Institute.

Hector Memorial Award, 1923.

DEAR SIR,—

The members of the committee appointed to make a recommendation for the award of the Hector Memorial Medal in Zoology for 1923 have had no easy task, owing to the difficulty of comparing work in different and distinct branches of zoology, but after careful consideration they are unanimous in recommending that the medal be awarded to Mr. G. V. Hudson, F.E.S., F.N.Z.Inst., for his long-continued and valuable researches in New Zealand entomology.

For the Committee.

CHAS. CHILTON, Convener.

Hutton Award for 1923.—The President read the recommendation of the Committee of Award (Professor Benham, Dr. Cockayne, Dr. Marshall, and Rev. Dr. Holloway), forwarding the name of Dr. J. Allan Thomson. On the motion of the President, it was unanimously resolved to confer the Hutton award on Dr. J. Allan Thomson.

Wellington, 13th January, 1923.

The Committee for the award of the Hutton Memorial Medal reports that, after considering the qualifications of various candidates, they recommend that it be awarded to Dr. Allan Thomson, on account of his geological work in New Zealand; of his valuable report on the Brachiopoda of the Australasian Antarctic Expedition, involving geographical distribution and recent and final representation; and, further, on account of his morphological work on Recent and extinct Brachiopoda, which sheds a new light on the relations of various genera.

WM. B. BENHAM, Convener.

Hamilton Prize for 1923.—The President read the recommendation of the referees appointed to advise on the prize (Dr. Chilton and Dr. Tillyard) and forwarding the name of Mr. J. G. Myers. On the motion of the President, it was unanimously resolved to award the prize to Mr. J. G. Myers.

Tongariro National Park.—The President gave an account of his attendance at the first meeting of the Park Board at Waimarino. It was resolved to pay the expenses of the President attending this meeting.

Catalogue Committee's Report.—This report, received 29th January, was read.

REFERENCE LIST OF SCIENTIFIC PERIODICALS.

A circular requesting lists of such periodicals was sent to sixty-two libraries and individuals, most of whom have supplied the details asked for. The information contained therein has been card-catalogued, and will only require certain details of editing to be made ready for the printer. The libraries of the Dominion Museum, Wellington Philosophical Society, and the New Zealand Institute, being under reorganization, have not yet supplied lists, but I understand that these will be forwarded as soon as details as to the ownership of certain periodicals have been decided.

GILBERT ARCHEY,
Hon. Editor, Reference List of Periodicals.

Fellowship.—It was resolved to declare two vacancies for the Fellowship for 1924.

Honorary Membership.—On the motion of Dr. Hilgendorf, seconded by Dr. Tillyard, it was resolved, That the qualifications for honorary membership as supplied by the nominators of each candidate be forwarded to members of the Board by the 15th December of each year.

The ballot for the vacancy of one member was then held, and resulted in Professor Bragg, F.R.S., being elected.

Canterbury College Jubilee.—The President and Professor Marshall were deputed to attend this celebration as delegates from the New Zealand Institute.

Pan-Pacific Congress, August, 1923.—On the motion of the President, seconded by Dr. Marshall, it was resolved, That Professors Chilton and Cotton should attend the Congress as delegates from the New Zealand Institute.

A letter from Mr. G. V. Hudson (27/12/22) was read and received.

Deaths of Honorary Members.—The deaths of the following honorary members were announced: Dr. D. Sharp, F.R.S.; Rev. R. H. Codrington, D.D.; Dr. G. S. Brady, F.R.S.

Officers for Year 1923.—The following officers for 1923 were elected: President, Professor H. B. Kirk; Hon. Secretary, Mr. B. C. Aston; Hon. Treasurer, Mr. M. A. Eliott; Hon. Editor, Mr. J. C. Andersen; Hon. Librarian, Professor C. A. Cotton. Trustees of the Hector, Carter, Hutton, and Hamilton Funds, Mr. B. C. Aston and Mr. M. A. Eliott.

Committees.—Research Committee: Mr. B. C. Aston, Professor W. P. Evans, Mr. F. W. Furkert, Dr. J. Allan Thomson.

Publication Committee: Professor H. B. Kirk, Dr. C. A. Cotton, Mr. J. C. Andersen, Dr. J. A. Thomson, Professor E. Marsden, and Mr. B. C. Aston.

Regulations Committee: Mr. J. C. Andersen, Dr. J. A. Thomson, Mr. M. A. Eliott, Mr. B. C. Aston, and Dr. C. A. Cotton.

Library Committee: Professor D. M. Y. Sommerville, Dr. J. Allan Thomson, and Dr. C. A. Cotton.

Hector Award Committee: Mr. T. F. Cheeseman, Dr. L. Cockayne and Professor Chas. Chilton.

Hutton Award Committee: Professor W. B. Benham, Dr. L. Cockayne, Dr. J. E. Holloway, Dr. P. Marshall, and Dr. J. A. Thomson.

Hamilton Prize Committee: Dr. Chas. Chilton, Dr. R. J. Tillyard, and Dr. P. Marshall.

Date and Place of Next Annual Meeting.—To be held in Wellington on last Tuesday in January, 1924.

Meetings of Standing Committee.—It was resolved, That the Standing Committee should meet at regular stated times, the first Tuesday in every month to be the ordinary dates of meeting, at 2 p.m. All members of the Board to be informed of any change in the regular date of meeting.

Reconstitution of Standing Committee.—Dr. Chilton moved, That the Regulation 17 be rescinded, with a view to reconstruct the Standing Committee on the lines proposed, as follows: That the Standing Committee consist of the President, the Hon. Secretary, the Hon. Treasurer, and three other members of the Board of Governors to be elected at the annual meeting of the Board of Governors. The motion was lost.

Minutes.—Authority was given the Standing Committee to confirm the minutes of this meeting.

Deer on Stewart Island.—On the motion of Dr. Marshall, seconded by Dr. Tillyard, it was resolved, That the Hon. G. M. Thomson be asked to

report to the Standing Committee on the increase and spread of white-tailed deer on Stewart Island, and the consequent damage to the native flora and fauna.

Hutton Grant Application.—Letters from Dr. Marshall, dated 6th June and 15th January, 1923, applying for a grant of £40 from the Hutton Fund, were read, and it was resolved, on the motion of the President, seconded by Archdeacon Williams, to grant the sum asked for the purpose of enabling Dr. Marshall to continue his identification in the study of Cretaceous fossils.

Carter Committee Report.—The report was received. On the motion of Professor Marsden, seconded by Professor Segar, it was resolved, That the Institute endeavour to obtain the permission of the Court to use £2,000 of the Carter Bequest money for the erection of an observatory according to the committee's report.

Report of the Carter Bequest Committee.

I regret that, owing to the absence of the Government Astronomer in Australia, my own absence in Samoa, and the distractions consequent on the meeting of the Australasian Association, the committee has been unable to complete the business for which it was set up. I therefore beg leave to present an interim report, and to ask that, if the Board of Governors sees fit, the committee should be continued for another year.

The terms of reference were to prepare plans for an astronomical observatory in accordance with the majority report of the committee previously set up.

I have to report that the committee was favourable to the idea of providing accommodation on a larger scale than was immediately required by the instruments at present available, and obtained from Messrs. Cooke, York, and Sir Howard Grubb, Buckingham, estimates for a dome to accommodate a 12 in. refracting telescope, the dome being some 25 ft in diameter. Cooke's estimates, which were the lower of the two, and were favoured by the committee, amount to £720; this does not include any building, but only the steel framework and covering for the actual dome.

I am in correspondence with Mr. La Trobe with regard to plans for a building, but there has not yet been sufficient time to prepare these.

D. M. Y. Sommerville, Convener.

Samoan Observatory Committee's Report.—This report was received. The committee was re-elected.

Report of the Samoan Observatory Board.

The Samoan Observatory Board has held four meetings in the last two years, at which the programme of researches at Apia and publications have been considered. Committees of the Board have also met on numerous occasions. The co-operation between the scientific representatives of the Institute and the representatives of the Government has been successful, and there is reason to believe that owing to the Board's activities the Minister has been assured that the scientific work of the Observatory has been kept at a high standard. The representatives of the committee require re-election.

MINUTES OF THE ANNUAL MEETING OF THE BOARD OF GOVERNORS.

29TH JANUARY, 1924.

THE annual meeting of the Board of Governors was held in Victoria University College, Wellington, on Tuesday, 29th January, 1924, at 10 a.m.

Present

President, Professor H. B. Kirk (in the chair), and the following Governors:

Representing the Government: Dr. Chas. Chilton, Dr. L. Cockayne, Dr. J. Allan Thomson, and Mr. B. C. Aston (Hon. Secretary).

Representing Wellington Philosophical Society: Mr. G. V. Hudson and Mr. P. G. Morgan.

Representing Auckland Institute: Professors H. W. Segar and F. P. Worley.

Representing Philosophical Institute of Canterbury: Dr. C. Coleridge Farr and Mr. A. M. Wright.

Representing Otago Institute: Hon. G. M. Thomson and Dr. J. Malcolm.

Representing Hawke's Bay Philosophical Institute: Mr. H. Hill.

Representing Manawatu Philosophical Society: Mr. M. A Eliott (Hon. Treasurer).

Representing Wanganui Philosophical Society: Dr. P. Marshall.

Representing Nelson Institute: Professor T. H. Easterfield.

Apologies for non-attendance were received from His Excellency the Governor-General and from the Hon. the Minister of Internal Affairs.

Presidential Address. Professor Kirk then read his presidential address. It was unanimously resolved to print the address, and a vote of thanks was carried by acclamation.

Resolution of Sympathy. - On the motion of the President, the members stood while honour was done to the memory of those members of the Institute who had died during the past year namely, Professor F. D. Brown, Mr. T. F. Cheeseman, Mr. R. Murdoch, and Mr. W. F. Worley; and Dr. Bayley Balfour, Honorary Member of the Institute; also Dr. Omori, the eminent Japanese seismologist.

Incorporated Societies' Reports.—The reports and balance-sheets of the following societies were laid on the table: Auckland Institute, for year ending 22nd February, 1923; Philosophical Institute of Canterbury, for year ending 31st October, 1923; Otago Institute, for year ending 30th November, 1923; Hawke's Bay Institute, for year ending 31st December, 1923; Manawatu Philosophical Society, for year ending 14th December, 1923; Nelson Institute, for year ending March, 1923; Wellington Philosophical Society (balance-sheet only), for year ending 30th September, 1923. No report was received from Wanganui Philosophical Society.

Poverty Bay Society.—A letter, dated 19th January, 1924, from the Venerable Archdeacon Williams, was read, intimating that there was no

hope of resuscitating the Poverty Bay Institute. On the motion of the President, it was resolved, That the Poverty Bay Institute henceforth ceases to be incorporated with the New Zealand Institute.

Standing Committee's Report.--This was received.

REPORT OF THE STANDING COMMITTEE FOR THE YEAR ENDING 31ST DECEMBER, 1923.

Meetings.—During the year nine meetings of the Standing Committee have been held, the attendance being as follows: Professor Kirk, 9; Professor Cotton, 5; Dr. Cockayne, 5; Dr. Marshall, 5; Dr. Marsden, 3; Mr. A. M. Wright, 2; Hon. Mr. Thomson, 1; Mr. M. A. Eliott, 1; Mr. B. C. Aston, 9.

Hector Award.—The award for 1922 was made to Mr. G. V. Hudson, F.N.Z.Inst., for his long-continued and valuable researches in New Zealand entomology.

Hutton Award.—The award for 1922 was made to Dr. J. Allan Thomson, on account of his geological work in New Zealand; of his valuable report on the Brachiopoda of the Australasian Antarctic Expedition, involving geographical distribution of recent and final representation; and, further, on account of his morphological work in Recent and extinct Brachiopoda, which sheds a new light on the relations of various genera.

Hamilton Prize.—This was the first year of awarding the Hamilton Memorial Prize, and the committee of award recommended that it be given to Mr. J. G. Myers, of Wellington.

Presentation of Hector, Hutton, and Hamilton Awards.—At a general meeting of the Wellington Philosophical Society held on Friday, 6th July, 1923, opportunity was taken to present the above three awards, the recipients in each case being members of the society. Professor Kirk, President of the New Zealand Institute, presented the Hector Medal to Mr. G. V. Hudson, the Hutton Medal to Dr. J. Allan Thomson, and the Hamilton Prize to Mr. J. G. Myers.

Publications. Transactions of the New Zealand Institute, volume 54: There has been a considerable delay in the publication of this volume, explained by the Hon. Editor in his report.

Dixon's Bulletin of Mosses: This work is in the press, and should be issued shortly. A delay occurred owing to one of the plates being mislaid in the Printing Office, and another one having to be prepared in England.

Major Broun's Bulletin, part 8 (the final part of this bulletin), was published during the year, and is now available for those who desire it at 3s. 6d. per copy to members and 5s. to non-members.

Exchange List.--During the year the following additions have been made to the exchange list:-

Deutsches Entomologisches Museum, Berlin.
Astronomical Society of the Pacific, San Francisco.
Staatlisches Forschingsenstitut für Volkerkunde, Leipzig.
New York State College of Agriculture.
Biological Station, Sarator, Russia.
Hungarian National Museum, Budapest.
Royal Survey of Western Australia.
Laboratorio di Zoologia Generale e Agraria, Portici.
University of Washington, U.S.A.
Ethnological Institute, Tubingen.
Wisconsin Academy of Sciences, U.S.A.
Staats und Universitatsbibliothek, Hamburg.
Musee d'Histoire Naturelle, Genève.

Sales.—A number of sets of *Maori Art* have been disposed of, and the revenue of the Carter Bequest has been increased by the sale of certain books written by the deceased.

Incorporated Societies' Annual Reports and Balance-sheets.—These were submitted to the Hon. Treasurer, Mr. Eliott, for his report on them. Mr. Eliott prepared a schedule showing the financial state of all the societies, excepting Poverty Bay Institute, which did not supply a balance-sheet or report, and suggested that a copy of the schedule should be sent to each society, enabling each one to see how the other societies were progressing, and possibly thereby create a healthy spirit of emulation. This suggestion was approved by the Standing Committee and carried out.

Reports have been received from the following societies, and are now laid on the table:—

- Auckland Institute, for year ending 22nd February, 1923.
- Wellington Philosophical Society, for year ending 30th September, 1923 (balance-sheet only).
- Philosophical Institute of Canterbury, for year ending 31st October, 1923.
- Otago Institute, for year ending 30th November, 1923.
- Hawke's Bay Philosophical Institute, for year ending 31st December, 1923.
- Manawatu Philosophical Society, for year ending 14th December, 1923.
- Nelson Institute, for year ending March, 1923.

Fellowship, New Zealand Institute.—On the 15th February, 1923, the appointment of Mr. J. C. Andersen and the Ven. Archdeacon Williams to the Fellowship of the New Zealand Institute was gazetted.

On the 7th April the incorporated societies were asked to send in nominations for the two vacancies in the Fellowship for 1924, and in response thirteen names were forwarded. These were submitted on the 2nd August to the Fellows for selection, and on the 3rd October the Hon. Returning Officer, Professor Segar, forwarded the results of the selection, and these names were then communicated to the Governors.

Stewart Island.—At the last annual meeting a resolution was passed to the effect that the Hon. G. M. Thomson be asked to report to the Standing Committee on the increase and spread of white-tailed deer on Stewart Island, and the consequent damage to the native flora and fauna. Mr. Thomson forwarded his report, which was considered at a meeting of the Standing Committee held on the 3rd July. The report is as follows:—

"The Virginian or white-tailed deer (*Cariacus virginianus*) was introduced into New Zealand in 1915, when two stags and seven hinds were liberated at the head of one of the arms of Port Pegasus, Stewart Island. From time to time reports were heard of their increase, but, as there is practically no settlement beyond a fishing-station in the inlet, it is difficult to get information. But Mr. W. J. Thomson, of Half-moon Bay, who has interests in the Port Pegasus station, has furnished me with some information which is thoroughly reliable. I quote from his letter to me of the 28th February:—

"'White-tailed deer are now thoroughly established on the south portion of the island, and it is only a question of time when they will be a curse—when their numbers will exceed what the place will carry. I have been through a goodly portion of the south part of the island in recent years, and have found little or no destruction to the bush, with the exception of one shrub, the 'five-leaved gum-tree' we call it [this is *Panax Colensoi*]. It is already doomed, as the deer are evidently very fond of it and eat the bark, which kills the tree. Otherwise the bush does not seem to suffer much damage, with the exception that all the young leaves within reach of the herd will be fair game. The only hope for the bush is to keep the deer well under control; once their numbers increase beyond the food-supply, then good-bye to all ferns and small shrubs. . . . Some time ago I tried, through some friends, to induce the Government to buy Cooper's Island (Ulva), in Paterson Inlet. This island is wonderfully adapted for a bird-sanctuary, being free of all pests, deer, &c. All the New Zealand ground-birds could be liberated there, and I have no doubt, with proper fostering, it could be the bird island of New Zealand.'

"I do not know that the Institute can do anything at the present time except to urge that the control of the animal life on the island should not be allowed to pass into the hands of any acclimatization society. When the time comes the deer should be thinned out, but it is hopeless to eradicate them, as most of the island is nearly inaccessible on account of the thick bush. Bushfelling should also be stopped on the island, as sawmill hands are the greatest enemies of the native avifauna.

"G. M. THOMSON."

After hearing the report the Standing Committee resolved to ask Mr. Guthrie-Smith to report on the whole matter of the preservation of the avifauna of Stewart Island. On the 26th July Mr. Guthrie-Smith replied that his visits to Stewart Island had been prior to the introduction of the Virginian deer; he mentioned that Ulva is at present badly infested with rats, which proved fatal to the South Island robin when liberated by Mr. Traill.

Mr. Guthrie-Smith regretted that deer had been liberated in Stewart Island, as the hills of the island were very barren and the deer were forced into the bush. He urged that an endeavour should be made to conserve all islands still virgin, big or small, along the coasts of New Zealand, also the Auckland or Campbell Groups and the Snares.

This report was received at a meeting of the Standing Committee held on the 7th August, when it was decided to thank Mr. Smith for his report, and to inform him that after his next visit to the island the Institute would be glad if he would report further on the matter.

At a meeting of the Standing Committee held on the 4th December, the Hon. Secretary gave some information in regard to the present owner of Ulva, and it was resolved to ask the Otago Institute to co-operate with the New Zealand Institute in endeavouring to create bird-sanctuaries on the Stewart Island region.

Native-bird Protection.—It was reported at a meeting of the Standing Committee held in December, 1922, that permission had been granted to certain persons to kill native birds for the Empire Exhibition. The President, Professor Kirk, wrote to the Hon. the Minister of Internal Affairs to ascertain the truth in regard to the report, and suggested to him that, if necessary, specimens for a bird exhibit could be obtained from the various collections in the museums. On the 29th January the Hon. the Minister replied that it was proposed to set up a national-history exhibit in the New Zealand Section of the Exhibition, and that it was desired as far as possible that a representative collection of New Zealand birds should be included in the exhibit. He mentioned that, with a view to ascertaining what specimens would be available, the several museums had been approached, and it appeared extremely doubtful that a suitable exhibit could be supplied from existing specimens. He assured the Institute that, should it be found necessary to take fresh specimens, authority to do so would be given only to approved persons.

This letter was read at a meeting of the Standing Committee held on the 6th February, when it was decided to set up a committee, consisting of the Hon. Mr. Thomson, Mr. J. C. Andersen, Major Wilson, and Mr. J. G. Myers, to compile a list of rare birds which should be suggested to the Hon. the Minister as deserving a special protection. And it was further resolved to ask the Hon. the Minister to allow the Institute to concur or dissent in any permit issued for the taking of native birds; or, if this is not acceptable, to refer the matter to the Board of Science and Art. The Hon. the Minister has replied that he is considering the matter.

On the 15th November the Hon. G. M. Thomson reported that a Bill on the subject of bird-protection had been passed in Parliament the previous session; it was amended and made more stringent during the past session, and the Bird Protection Society was formed, which has broadcasted information of the subject throughout the country, so that there was nothing more that the committee appointed by the Standing Committee could do.

Travelling-expenses.—At last annual meeting it was resolved that the opinion of incorporated societies be taken on the question of pooling the expenses of members of the Board when attending annual meetings of the Institute, and each society paying its share, an estimate of the cost, under this proposal, being sent to each society. This was done, and the societies replied as follows: Wellington Philosophical Society, Philosophical Institute of Canterbury, Otago Institute, Manawatu Philosophical Society, and Nelson Institute all agreed to the proposal: Wanganui Philosophical Society would prefer to pay the expenses of its own representative; Auckland Institute and Hawke's Bay Institute do not agree to the proposal; Poverty Bay Institute has not replied.

Carter Bequest. At the last annual meeting it was resolved that the Institute endeavour to obtain the permission of the Court to use £2,000 of the Carter Bequest moneys for the erection of an observatory according to the committee's majority report. At a meeting of the Standing Committee held on the 7th April it was resolved to ascertain what the cost of applying to the Supreme Court for a declaratory judgment would be, and whether the cost could be met from the Carter funds. The Board's legal advisers were accordingly consulted, and on the 11th June an opinion was received from them in which they stated that they were unable to make an estimate of the cost of an application by the Institute to the Court by reason of the uncertainty into what direction the proceedings might develop. The Standing Committee considered this opinion, and it was resolved that a committee, consisting of the President, Dr. Marshall, and Mr. Aston, be appointed a committee to report.

The resolution of the annual meeting referred to above was then referred to the solicitors, and at a meeting of the Standing Committee held on the 17th August an opinion from them, dated 31st July, was read. It concluded with the following statement: "To ask the Court to authorize £2,000 to be paid out of the fund for a small observatory is a departure from the objects the Institute had in view at the time of that last-mentioned minute—namely, to 'hasten the increase of the fund towards the realization of the testator's wishes.' It means the establishing of two observatories,

when the testator, as we think, meant only one. We are of opinion the resolution of January, 1923, should not have been passed, and that the Board of Governors should reconsider it with a view to its rescission." It was resolved to forward copies of both these opinions to members of the Board of Governors and to members of the Carter Bequest Committee, and that further action be suspended until the annual meeting.

Management of Trust Funds.—At last annual meeting a resolution was passed to the effect that half of 1 per cent. of the capital invested on account of the Carter, Hector, Hutton, and Hamilton Trust Funds be contributed by these funds towards the cost of administration.

At a meeting of the Standing Committee held on the 6th February it was resolved that before ½ per cent. is deducted from the trust funds the Standing Committee should take steps to ascertain that it can legally do so. Accordingly the Board's legal advisers were consulted, and they gave it as their opinion that the Board of Governors can lawfully expend a reasonable amount of the income of the funds in expenses of management. The Standing Committee resolved, however, that the resolution of the annual meeting regarding the allocation of a portion of trust funds for management expenses be held in abeyance until after the next annual meeting.

Storage of Books.—With the removal of the office and library of the Institute to Victoria College the matter of the storage of the stocks of publications which had been stored in the attic of the Museum became urgent. The Hon. G. M. Thomson had previously made representations to the Internal Affairs Department regarding the possibility of obtaining a suitable room in the Parliamentary Buildings for the surplus stocks, and on the 1st February a room in the basement of the old Parliamentary Buildings was promised to the Institute. Difficulties arose, however, in regard to securing the room, as the Public Works Department had some claim to it. When the removal of the office and library to Victoria College took place the Acting Director of the Museum had the Institute's books removed to a small room in the basement of the Parliamentary Buildings. This room is not suitable, as at present it is also used for other purposes, and there is no space available in it to allow of sorting the Institute's publications into any kind of order.

Hon. Treasurer's Visit to Europe.—On the 22nd March the Hon. Treasurer applied for six months' leave of absence, as he desired to visit Europe. At a meeting of the Standing Committee held on the 11th April the necessary leave was granted, and a letter of introduction to scientific bodies was given to Mr. Eliott. It was resolved that during the Hon. Treasurer's absence the President be authorized to sign cheques conjointly with the Hon. Secretary.

Dominion Museum.—During the year the matter of the lack of suitable Museum buildings was brought prominently before the Acting Prime Minister, Sir Francis Bell, by a deputation of Wellington members of Parliament. The question of sites was discussed, and Mount Cook site, Sir Francis Bell said, was looked upon most favourably by the Government. The immediate result is that in the meantime some of the most valuable exhibits are to be stored in fireproof rooms in the Dominion Farmers' Institute Buildings.

Contoured Topographical Map of New Zealand.—At the annual meeting in 1920 a resolution was passed urging the necessity of a contoured topographical map. The Lands and Survey Department has to be congratulated on the very fine maps which it has issued of the Dunedin and Wellington districts.

Resolutions passed by the Standing Committee during the Year and not otherwise mentioned in the Report.

1. On the 11th April it was resolved to pay any travelling-expenses incurred by the President in attending the Tongariro National Park Board.

2. On the 11th April it was resolved, That, in the case of any amendment to the Tongariro National Park Act, the Government should be approached in the direction of allowing the New Zealand Institute to have a representative elected by the Institute, who would not necessarily be the President, as it is customary to hold the office of President for only two years.

3. On the 12th June Professor Cotton intimated that he was unable to continue to act as Hon. Librarian, and it was resolved to appoint Professor Kirk in his place.

4. On the 12th June it was resolved to bind a complete set of the *Transactions* of the Institute in buckram for the library. This work is nearly completed: it was held up owing to the binder having to order fresh supplies of buckram from England.

The report was discussed clause by clause.

Hector Medal.—It was resolved that in future the Award Committee of the year be asked to suggest the inscription which should be placed on each medal; the attention of the committee to be directed to the previous inscriptions in volume 53.

Stewart Island Sanctuary. On the motion of Dr. J. A. Thomson, seconded by Dr. Cockayne, it was resolved, That the control of the animal life on Stewart Island should be retained by the Government and should not be allowed to pass into the hands of any acclimatization society.

Travelling-expenses.—On the motion of Mr. Wright, seconded by Dr. J. A. Thomson, it was resolved, That the New Zealand Institute pay the travelling-expenses of members of the Board of Governors.

Proposal to charge Expenses for managing Trust Funds.—On the motion of the President, seconded by Mr. Eliott, it was resolved to rescind the resolution passed at last annual meeting empowering the Board to deduct ½ per cent. of the capital of the trust funds for management expenses.

Storage of Stock of Publications.—It was resolved to leave the matter of the storage of the immense stock of publications held by the Institute to the Standing Committee.

Dominion Museum.—On the motion of Dr. Farr, seconded by Mr. Hill, it was resolved, That the New Zealand Institute urge the Government to proceed at the earliest possible moment with the erection of a suitable building for the Dominion Museum in Wellington.

The Standing Committee's report was amended and adopted.

Hector Award for 1924.—The President then read the report of the Committee of Award recommending the award of this medal to Mr. D. Petrie for his botanical work. The recommendation of the committee (Drs. Chilton and Cockayne) was unanimously adopted.

Ngaio, Wellington, 5th January, 1924.

The President, New Zealand Institute.

DEAR SIR,—

We, the members of the Recommendation Committee, having carefully considered the claims of those botanists we judge eligible for the Hector Medal and Prize, unhesitatingly recommend the award to be made to Mr. Donald Petrie, M.A., F.N.Z.Inst., on account of his pioneer investigations of the distribution of the plants of Otago and Stewart Island, which brought forth much information essential for New Zealand plant-geography, together with his further botanical explorations in most parts of the North and South Islands, carried out year by year since 1876, and his many contributions towards a more accurate knowledge of the flora of New Zealand.

In making this recommendation we have greatly missed the advice of our late distinguished colleague, Mr. T. F. Cheeseman, whose death we deeply deplore, but we feel assured that he would have fully agreed with our decision.

LEONARD COCKAYNE, Convener.
CHAS. CHILTON.

Financial Reports.—On the motion of the Hon. Treasurer, the following financial statements for the year ending 31st December, 1923, which had been duly audited by the Auditor-General, were adopted: Statement of Receipts and Expenditure; Statement of Research Grants; Statement of Assets and Liabilities; Statement of Carter, Hector, Hutton, and Hamilton Trust Accounts.

HONORARY TREASURER'S REPORT FOR YEAR ENDING 31ST DECEMBER, 1923.

The statement of assets over liabilities shows a very satisfactory position. The credit balance has increased from £233 1s. 5d. on the 31st December, 1922, to £869 15s. 3d. on the 31st December, 1923, the surplus from the year's working being £636 13s. 10d.

With regard to the Government research grants, the total amount paid out to various applicants, less refunds, amounts to £285 6s. 10d.; and, as no further grants have been received from the Treasury, the fund has now been reduced to £971 5s. 8d.

The various trust accounts are in a healthy state. The Carter Bequest Capital Account has grown from £5,155 1s. 10d. to £5,455 15s., the revenue for the year, earned from investments in Government bonds, amounting to £320 17s. 2d., which is equal to 6·2 per cent. on the amount standing to the credit of the Capital Account on the 31st December, 1922. This fund will continue to grow, as the interest is being reinvested in Government bonds as it accumulates. The investments of the Hector and Hutton Memorial Funds give a return of 5 82 per cent.

The books and accounts have been well and accurately kept by the Assistant-Secretary.

M. A. ELIOTT, Hon. Treasurer.

NEW ZEALAND INSTITUTE.—STATEMENT OF RECEIPTS AND EXPENDITURE FOR THE YEAR ENDING 31ST DECEMBER, 1923.

Receipts.	£	s.	d.
Balance as at 31st December, 1922	2,168	4	6
Petty cash as at 31st December, 1922	6	3	10
Statutory grant	1,000	0	0
Publications sold	131	17	11
Refunds by research grantees	41	7	10
Interest, Post Office Savings-bank	64	1	1
Interest on Endowment Fund invested in inscribed stock	5	0	0
Contributions to Publication Fund	2	10	6
Interest, Carter Legacy, £50	2	5	0
Interest on Carter Bequest	318	15	0
Interest on Hector Fund	68	10	0
Interest on Hutton Fund	58	10	0
Interest on Hamilton Fund	1	2	6
Refund from Carter Bequest, Post Office Savings bank Account	155	5	6
Refund from Hutton Memorial Fund	9	0	0
	£4,032	13	8

Expenditure.	£	s.	d.
Government Printer	449	17	3
Petty cash (postages)	15	15	2
Salaries	258	6	8
Charges (bank commission, premiums)	4	13	4
Travelling-expenses	39	11	4
Adlard and Son (plates)	3	6	9
Library removal (cartage assistance)	22	4	9
Hector Prize for 1922	45	0	0
Carter interest reinvested	300	13	2
Hutton Fund research grant	40	0	0
Research grants, as per list	326	14	8
Endowment Fund invested	198	19	4
Hamilton Prize	4	0	0
Carter Fund—Interest to Account	180	5	8
Hutton Fund—Interest to Account	27	10	0
Balance as under	2,115	15	7
	£4,032	13	8

	£	s.	d.
Balance in Bank of New Zealand	62	7	2
Balance in Post Office Savings-bank	2,042	19	9
Petty cash in hand	10	8	8
	£2,115	15	7

Made up as follows:–

	Dr. £	s.	d.	*Cr.* £	s.	d.
Endowment Fund Revenue Account ..	..			63	14	4
Government Research Grant balance ..	..			971	5	8
Library Fund	..			245	15	0
Hector Fund overdrawn	6	14	10	..		
Hamilton Fund overdrawn	0	3	11	..		
	1	14	10	..		
Sundry debtors	12	12	6	..		
Carter Bequest Revenue Account ..	..			35	8	11
Hutton Memorial Fund Revenue Account	..			20	11	10
Wheldon and Wesley in credit ..	..			0	4	3
Carter Legacy -Interest on £50 ..	..			2	5	0
Carter Bequest—Post Office Savings-bank Account	35	8	11	..		
Hector Memorial Fund—Post Office Savings-bank Account	14	15	2	..		
Hutton Memorial Fund—Post Office Savings-bank Account	20	11	10	..		
Hamilton Memorial Fund—Post Office Savings-bank Account	1	2	8	..		
Profit on year's work . ..	..			869	15	3
	£93	4	8	£2,209	0	3
				93	4	8
				£2,115	15	7

Examined and found correct J. H. Fowler, Deputy Controller and Auditor-General.

M. A. Eliott, Hon. Treasurer.

New Zealand Institute.–Statement of Liabilities and Assets as at 31st December, 1923.

Liabilities.	£	s.	d.
Carter Bequest Capital Account	5,455	15	0
Hector Fund Capital Account	1,184	18	1
Hutton Fund Capital Account	1,014	5	10
Hamilton Fund Capital Account	48	7	11
Endowment Fund Capital Account	198	19	4
Carter Bequest Revenue Account	35	8	11
Hutton Fund Revenue Account	20	11	10
Endowment Fund Revenue Account	63	14	4
Government research grants—Balance	971	5	8
Library Fund	245	15	0
Carter Legacy—Interest, £50	2	5	0
Wheldon and Wesley, in credit	0	4	3
Balance of assets over liabilities	869	15	3
	£10,111	6	5

Assets.	£	s.	d.
Inscribed stock, Discharged Soldiers Settlement Loan, £7,650	7,068	2	11
Post Office inscribed stock, £800	785	15	4
Government war bonds, £50	48	11	10
Hector Fund—Revenue Account overdrawn	6	14	10
Hamilton Fund—Revenue Account overdrawn	1	14	10
Cash in Bank of New Zealand	62	7	2
Cash in Post Office Savings-bank	2,042	19	9
Cash in Post Office Savings-bank—Carter Account	35	8	11
Cash in Post Office Savings-bank—Hector Fund Account	14	15	2
Cash in Post Office Savings-bank—Hutton Fund Account	20	11	10
Cash in Post Office Savings-bank—Hamilton Fund Account	1	2	8
Petty cash in hand	10	8	8
Sundry debtors	12	12	6
	£10,111	6	5

New Zealand Institute.—Government Research Grants for Year ending 31st December, 1923.

1923.			*Dr.* £	s.	d.	*Cr.* £	s.	d.
Jan. 1.	By	Balance	..			1,256	12	6
Mar. 1.		Mr. W. G. Morrison—Refund	..			26	19	7
April 4.		Professor Easterfield—Refund	..			8	0	6
Dec. 20.		Dr. Adams—Refund	..			6	7	9
Jan. 8.	To	Professor Easterfield	100	0	0	..		
Feb. 24.		Professor Evans	94	13	10	..		
		Professor Farr	2	4	8	..		
		Dr. Hilgendorf	2	10	0	..		
		Dr. Marsden	5	0	4	..		
		Professor Malcolm	16	13	4	..		
Aug. 8.		Dr. Marshall	25	0	0	.		
		Dr. Allan	10	0	0	.		
Sept. 20.		Dr. Hilgendorf	16	5	6	..		
Oct. 8.		Professor Worley	9	7	0	..		
Nov. 15.		Dr. Marshall	25	0	0	..		
" 28.		Dr. Adams	20	0	0	..		
Dec. 31.		Balance	971	5	8	..		
			£1,298	0	4	£1,298	0	4

New Zealand Institute Trust Accounts.

Carter Bequest Revenue Account for Year ending 31st December, 1923.

	£	s.	d.		£	s.	d.
To Interest invested in inscribed stock ..	300	13	2	By Balance	8	6	6
Balance	35	8	11	Books sold by auction ..	4	13	4
				Books exchanged for *Transactions*	2	5	0
				Interest on investments ..	318	15	0
				Interest, Post Office Savings-bank	2	2	3
	£336	2	1		£336	2	1
				By Balance	£35	8	11

Hector Memorial Fund Revenue Account for Year ending 31st December, 1923.

	£	s.	d.		£	s.	d.
To Balance	30	19	9	By Interest on investments ..	68	10	0
Cheque, Dr. Farr (prize) ..	45	0	0	Interest, Post Office Savings-bank	0	14	11
				Balance	6	14	10
	£75	19	9		£75	19	9
To Balance	£6	14	10				

Hutton Memorial Fund Revenue Account for Year ending 31st December, 1923.

	£	s.	d.		£	s.	d.
To Research grant, Dr. Marshall	40	0	0	By Balance	1	7	1
Balance	20	11	10	Interest on investment ..	58	10	0
				Interest, Post Office Savings-bank	0	14	9
	£60	11	10		£60	11	10
				By Balance	£20	11	10

Hamilton Memorial Fund Revenue Account for Year ending 31st December, 1923.

	£	s.	d.		£	s.	d.
To Cheque, Mr. Myers (prize)	4	0	0	By Interest on war bonds ..	2	5	0
				Interest Post Office Savings-bank	0	0	2
				Balance	1	14	10
	£4	0	0		£4	0	0
To Balance . ..	£1	14	10				

Levy on Incorporated Societies for Volume 55.—On the motion of Mr. Hill, seconded by Mr. Eliott, it was resolved, That the levy for volume 55 be 5s. for the combined volume.

Research Grant Report.—This report was adopted. On the motion of Professor Worley, seconded by Dr. Marshall, it was resolved, That this meeting of the Board of Governors strongly urges the Government to reinstate an adequate research grant to be administered by the New Zealand Institute, and that the following gentlemen form a deputation to wait on the Government: The President and President-Elect, Hon. Mr. G. M. Thomson, Dr. J. A. Thomson, Dr. L. Cockayne, and Professor T. H. Easterfield.

Research Grant Report for Year ending 31st December, 1923.

Dr. C. E. Adams, who in 1919 was granted, through the Wellington Phoilsophical Society, £55 for purchasing astronomical instruments for the Astronomical Section of the society, was during the year granted a further £20 in order to complete the mounting of certain instruments. Dr. Adams reported on the 11th December that this work is progressing.

Dr. C. E. Adams, on the 11th December, refunded £6 8s. 3d., balance of a grant for investigating astronomical and geophysical sites in Otago.

Dr. H. H. Allan during the year was granted, through the Philosophical Institute of Canterbury, £30 for a research on the selection and breeding of valuable economic strains in rye-grasses and cocksfoot. On the 26th November Dr. Allan reported that he was investigating these grasses along the lines of persistency, abundance of herbage, quality, disease-resistance; also investigating the life-histories of the various growth forms to be found in both species, the root-development in detail, the effect on both

species of various grasses and clovers commonly used in mixtures with them, and the yield of seed from various methods of growing—namely, broadcast and Danish system—and the effect of seed-treatment in germination. Some seventy-five samples of seed have been obtained from various countries, and a spring sowing has been made from each sample. The Board of Governors and the Director of the Agricultural High School in Feilding have allotted the required areas of ground, and provision has been made for areas required as the work extends. So far the only expenditure has been £2 2s. 9d. The Institute has a balance in hand of £20, and Dr. Allan the remainder.

Dr. Hilgendorf, convener of the Artesian Wells Committee, which in 1921 was granted, through the Philosophical Institute of Canterbury, £100, reported on the 6th December that early in the year recorders were erected in several country wells to obviate the interference observed in the town wells from the pumping from adjacent wells. Also, a recorder was erected in the River Avon with the object of elucidating the cause of some of its fluctuations. Observations were steadily carried out throughout the year, and it is proposed to continue until enough accumulates to justify publication. The apparatus required has been made free by Canterbury College and Lincoln College, and the balance of the grant, which is in the hands of the Institute, is £41 8s. 8d.

Mr. Brittin, who in 1919 was granted, through the Philosophical Institute of Canterbury, £100 for research into fruit-diseases, reported on the 16th December that owing to ill health he had been unable to continue the research, and he deemed it advisable to give up all further work in connection with the grant. The balance in the hands of the Institute is £80.

Professor Burbidge, who in 1921 was granted, through the Auckland Institute, £100 for a research on the intensity of long-wave wireless, reported on the 26th December that apparatus had been installed. Signals were received, but not in proper intensity, and the apparatus had been redesigned. This involved putting in measured high resistance and small capacities (for a resistance capacity amplification), and these adjustments have taken considerable time. This, combined with lack of time from routine work for research, has accounted for delay in getting measurements, but this year the work should be well on the way with measurements. During the year Professor Burbidge was granted an additional £25, as the apparatus purchased absorbed all the £100. So far the Institute still has the £25.

Dr. Curtis, who in 1920 was granted, through the Nelson Institute, £100 for research in parasitic mycology, reported on the 20th December that the work carried out during the year was in preparation for the press. The whole of the grant was expended in books.

Mr. W. C. Davies, who in 1921 was granted, through the Nelson Institute, £50 for research on soil bacteria and protozoa, reported on the 20th December that pressure of routine work had prevented rapid progress of the investigations, but useful results have been obtained from the experiments in connection with some of the more barren soils of the Nelson District and in the partial sterilization of hothouse soils. The whole of the grant has been expended.

Professor Easterfield, who in 1921, through the Nelson Institute, was granted £200 for investigations in orchard chemistry, reported on the 20th December that work had been systematically carried out throughout the year in the direction of improving the spreading-power of sprays and studying the effect of different cool-store conditions on the keeping-quality of fruit. Observations have been carried out in three stores, using different systems of cooling, upon the most commonly stored varieties of fruit picked in different types of soil. Sufficient data has been collected to allow of certain deductions to be drawn. An account of the experiments and the results will be published shortly. The experiments are being continued. £100 has been expended as part salary of an orchard chemist, who has given his whole time to the work.

Professor Easterfield, who in 1919, through the Wellington Philosophical Society, was granted £250 for an investigation of mineral oils, reported on the 20th December that the research had been completed as far as is at present practicable, and the balance of £8 0s. 6d. has been refunded. The results of the investigation have been published in *Chemistry and Industry Review*, vol. 42, No. 39, p. 936 (London, 28th Sept., 1923).

Professor Evans, who in 1918–21, through the Philosophical Institute of Canterbury, was granted £600 for a research on New Zealand brown coals, reported on the 29th November that owing to unfavourable conditions no further work had been possible, and he considered it best to resign the balance of the grant—namely, £125 6s. 2d. This amount is in the hands of the Institute.

Dr. C. C. Farr, who in 1921 was granted, through the Philosophical Institute of Canterbury, £75 (£60 of which was transferred to another grant) for a research on the physical properties of gas-free sulphur, reported on the 11th January that during the

past year work had proceeded, and, although difficulties had arisen, as always in physical work, they were being overcome, and it is hoped shortly to be able to say something definite as regards the interesting problems solved. The balance of the grant is £12 15s. 4d., which is in the hands of the Institute.

Dr. C. C. Farr, who, through the Philosophical Institute of Canterbury, was during the year granted £30 for a research on the relationship between radium-emanation and goitre, reported on the 11th January, 1924, that experimental work in connection with this investigation was being undertaken by Mr. Rogers, who has re-examined the radium-emanation content of certain school wells near Christchurch and at Timaru, with a view to comparing it with the goitre incidence in the same schools. The question of the iodine-content of the same water is also being gone into. It is hoped to carry the research further during the year. So far the only expenditure has been in travelling-expenses. The grant has not yet been called on.

Mr. H. J. Finlay, through the Otago Institute, was during the year granted £10 for the purchase of books on palaeontology. On the 4th December Mr. Finlay reported that certain of the works had been received from Paris and the remainder were being forwarded. The grant has not yet been called on.

Mr. F. W. Foster, who during the year was granted £25 for the work of collating the manuscripts of the late Sir David Hutchins, reported on the 28th November that he had spent a good deal of time in sorting out the notes and placing them in some order. He found that sections on certain important aspects of New Zealand forestry were missing, and some time was spent in going through the library of the deceased, and eventually he found the missing sections and some other valuable manuscripts whose existence was not previously suspected. He is arranging the matter under three main heads: (1) Native forests and forest trees of mid and southern New Zealand; (2) exotic trees and plantations; (3) New Zealand forest policy. Mr. Foster reports that the work is proving far more protracted than he at first anticipated, but most of the matter so far dealt with is of a valuable nature. No portion of the grant has yet been paid over.

Mr. H. Hamilton was, through the Wellington Philosophical Society, granted £30 for a research on cave fauna of New Zealand. On the 5th December Mr. Hamilton reported that he has not yet undertaken the research, but he intends visiting Waitomo Caves at an early date.

Professor Inglis, who, through the Otago Institute, was granted £25 for a research on the essential oils of native plants, reported on the 29th November that larger distillation apparatus had been ordered, and preliminary work on a number of plants had already been done with his smaller apparatus. Next year the work will be carried on with the new apparatus, and an arrangement has been made with Professor Worley, who is working on a similar research, to avoid overlapping, and first experiments will be made upon (*a*) *Dacrydium cupressinum*, (*b*) *Dacrydium biforme*, (*c*) *Aciphylla*, (*d*) *Myoporum laetum*.

Professor Jack, who, through the Otago Institute, was in 1917 granted £25 for a research of the electric charge on rain, reported on the 20th December that further investigations had been carried out during the year, and the work was sent forward as a thesis. Professor Jack is now ordering new apparatus so that the work will be advanced further.

Mr. E. K. Lomas, who, through the Wellington Philosophical Society, was during the year granted £25 for a research on the intelligence of school-children, reported on the 20th December that he hoped to commence the research early in the year.

Professor Malcolm, who, through the Otago Institute, in 1919-21 was granted £425 for a research on the food value of New Zealand fish, reported on the 22nd December that early in the year a paper on the chemistry of the New Zealand paua was finished and sent for publication in the *Transactions* as Part IV of the series. Later in the year a special research was begun in conjunction with Mr. C. L. Carter, M.Sc., on the nature of the fats and oils in the mutton-bird. This is likely to throw light on the digestibility of the oils derived from the fish consumed by the bird. He hopes to publish results next year. Balance of the grant, which is in hands of Institute, is £68 6s. 8d.

Professor Malcolm, who, through the Otago Institute, in 1918 was granted £30 for a research on the New Zealand plant poisons, reported on the 22nd December that a considerable number of observations had been made as opportunity offered on tutin, pukateine, and karaka, and these will be published when completed. Some useful books bearing on the subject have been procured, and Dr. Rawnsley has prepared a thesis on convulsive poisons, including tutin, and it is hoped to publish these later. Balance of grant is £9 0s. 7d., which grantee holds.

Dr. Marshall, who, through the Wanganui Philosophical Society, during the year was granted £30 for a research on Upper Cretaceous fauna of New Zealand, reported on the 23rd November that he had made three collecting-visits to the north of Auckland (Whangaroa and Kaipara), and he had collected some forty-five species of ammonites. The whole year had been spent in identifying and classifying these. The extensive literature, and difficulty in preparing specimens and making the necessary drawings, hao taken much time, but the research is now almost ready for publication. Grantee has had the whole of this grant.

Mr. J. G. Myers, who, through the Wellington Philosophical Society, was during the year granted £10 for a research on the New Zealand Hemiptera, reported on the 27th November that, as the season for collecting was commencing, he hoped to commence his research.

Professor Speight, who, through the Philosophical Institute of Canterbury, in 1919 was granted £225 for a geological survey of the Malvern Hills, reported on the 11th December that during the year an examination had been made of various parts of the district, including the Rakaia Gorge, High Peak, Rockwood, and Benmore areas, the first two largely with the help of students, who had used those areas for subjects for M.A. and M.Sc. theses. A paper dealing with the last-named area was read by Professor Speight before the Philosophical Institute of Canterbury, and will be sent to the Hon. Editor of the *Transactions* for publication. Some attention has also been given to the more promising Glenroy and Steventon area, the latter being specially promising, and if systematically bored would probably prove to be a fairly extensive brown-coal field. The work in connection with these areas has reached such a stage that it is advisable to deal with the possibilities of the clays and sands for the purposes of earthenware, brick, and other manufactures.

Mr. Page, B.Sc., late assistant to Professor Evans, of Canterbury College, made a proposition to Mr. Speight dealing with this aspect of the matter, and Mr. Speight obtained the approval of the Standing Committee to divert portion of the grant to carrying out investigation on the clays. The balance of the grant in hands of Institute is £175.

Messrs. Wild and Tankersley, who, through the Philosophical Institute of Canterbury, were during the year granted £25 for soil survey work in the Manawatu district, reported on the 27th November that they had arranged to get the use of the chemical balance obtained by the Hon. Mr. G. M. Thomson for his research on whale-feed. Some material had been collected and preliminary work begun. No expenditure had so far been incurred.

Professor Worley, who, through the Auckland Institute, during the year was granted £25 for a research on the essential oils of native plants, reported on the 29th November that research had been carried out on the essential oil of *Leptospermum scoparium*, and is partly completed. Additions and alterations have been made to the distillation apparatus, and expenditure to the amount of £9 7s. incurred. Balance in hands of Institute, £15 13s.

Mr. A. M. Wright, who, through the Canterbury Philosophical Institute, was in 1921 granted £75 for a research on the vitamine-content of commercial meat products reported on the 4th December that, owing to its being impossible to procure a supply of white rats for further experimental work on the presence or otherwise of Vitamine C in frozen foods, and also for the purpose of determining the effect of dietary modifications to include various canned meats, the most important work planned in connection with this investigation had been postponed. The method of determining the presence of Vitamine B by the yeast culture method had been further investigated, but until animal experiments are carried out in parallel the results obtained may be of doubtful value. Three papers have been published covering the results obtained, and these have been published in the *Journal of the Society of Chemical Industry*, and in vol. 4, Nos. 2 and 3, *New Zealand Journal of Science and Technology*. Balance of grant in hands of Institute is £25.

Hutton Fund Research Grants.

Professor Marshall, who in 1923 was granted £40 to enable him to continue his work on the Upper Cretaceous ammonites of New Zealand, reported on the 22nd November that the work has proved to be of considerable complexity and difficulty, but it is now almost ready for publication.

Miss Mestayer, who in 1918 was granted £10, reported on the 4th December that owing to college lectures she was unable to publish any papers on Mollusca this year. She has material waiting which she hopes to describe and figure during 1924. There is still a balance of £5, which she hopes to use next year.

Research Work.—At the last annual meeting the following resolution was passed: "That the Research Grant Committee be asked to make a comprehensive report on the state of all researches undertaken with the Institute's financial aid during the last ten years." The following report has therefore been compiled, and a property list containing the books and apparatus, &c., bought out of the Research Grant Fund is appended.

REPORT ON THE RESEARCH WORK OF THE NEW ZEALAND INSTITUTE, MAY, 1923.

Dr. C. E. Adams in 1919 was granted £55, as Chairman of the Astronomical Section of the Wellington Philosophical Society, for the purchase of astronomical instruments. The British Astronomical Association purchased for him a micrometer eye-piece, wedge photometer, and objective prism. The last instrument was purchased in 1922, when Dr. Adams applied for an additional grant of £20 for mounting and cost of camera. This application was granted on the 12th June, 1923.

Dr. C. E. Adams in 1919 was granted £150 to enable him to undertake systematic observations in Central Otago, and such other localities as decided on by the Astronomical Section, to test the seeing and other conditions of sites for an observatory. In 1921 the Internal Affairs Department stated that, as the expenses in connection with the testing of sites was being undertaken by the Department, the grant would not be required Dr. Adams had expended £26 5s. 5d. on instruments, and he asked permission to retain these for another year, which permission was granted. The balance of the grant was surrendered.

Mr. L. Birks in 1916 was granted £10 for carrying out experiments in electrical prevention of frosts in orchards. In 1919 Mr. Birks was transferred from Christchurch to Wellington, and he refunded the grant, of which nothing had been expended.

Mr. C. Brittin in 1919 was granted £100 for a research in fruit-tree diseases. The work consisted in special pruning and spraying, and noting the effects. He had secured the loan of a microtome, and was able to prepare sections of the later stages of some of the diseases. Dr. Curtis, of Cawthron Institute, was assisting in the examination of the fungus causing die-back. The results of the experimental work in regard to pruning and spraying were satisfactory, but final results have not yet been reached. The expenses so far have been slight, and certain orchardists have gladly loaned their trees for the research. Mr. Brittin gave an address before the Fruit-growers' Association, and this was published in the *Nelson Mail* on the 7th October, 1922.

Professor P. W. Burbidge in 1921 was granted £100 for a research on the intensity of long-wave signals from Europe. The apparatus, which cost over £100, arrived towards the end of 1922, and Professor Burbidge reported that it was being assembled and a commencement being made. He applied for an additional £25 for current out-of-pocket expenses. This application was granted on the 12th June, 1923.

Dr. Chas. Chilton in 1918 was granted £50 for an investigation of New Zealand flax, particularly with a view to determining the varieties that will give the fibre of greatest economic value, and of the best conditions of cultivation for these varieties. Mrs. Jennings carried out the investigations, and made considerable progress, more particularly in the direction of commencing observations and experiments in regard to the diseases affecting the flax, improved methods of cultivation, &c. Early in 1919 Mrs Jennings (then Mrs. Dr. McCallum) had to leave for England; the work had to remain incomplete, and the unexpended portion of the grant—namely, £39—was refunded.

Dr. K. M. Curtis in 1920 was granted £100 for a research in parasitic mycology. In studying the early stages in the penetration of the germ-tube of the black-spot fungus into several varieties of pear it was found that varietal peculiarities, correlated with the relative susceptibility of the host, and of a degree sufficiently marked for advantage to be taken of them by selection in breeding, were not exhibited either by the fungus as it penetrated the host plant, or by the host itself as the result of that penetration. Owing, therefore, to the absence of sufficiently marked infectional peculiarities, this work has been concluded and attention directed instead to brown-rot of stone-fruits. The whole of the grant has been expended in books, the apparatus required in the research being available in the Cawthron Institute.

Mr. W. C. Davies in 1921 was granted £50 for a research on soil-bacteria and protozoa. The work included investigation of the bacteria of several typical soils of the Nelson district, particularly of the loams of the Moutere and Port Hills. Work also been commenced on the soils of the Nelson tomato-houses, with the object

of identifying the protozoa and studying the effects of several methods of partial sterilization of the soil-life. A laboratory has been fitted up, and experimental work in plate and pot culture has been carried out. The whole of the grant has been expended in apparatus and books.

Professor T. H. Easterfield in 1918-19 was granted £250 for an investigation in the wax-content of New Zealand brown coals. A commencement with the work was delayed owing to the war and the illness of Professor Easterfield's assistant. In 1921 a paper embodying the results of this investigation was read at the Science Congress in Palmerston North. In this paper the location of mineral oils was given, and allusion was made to the attempts to supply mineral-oil by distillation of oil-shales at Orepuki. The sulphur-content of the southern shales was stated to be a serious objection. Comparison of the properties of Taranaki and Kotuku oil was given. Professor Easterfield stated that in his opinion the boring of new wells in Taranaki promised at present greater success than development in any other area, but urged that as a matter of Imperial interest systematic prospecting by bores should be carried out in a number of areas. The grant was expended in the salaries of assistants, and the unexpended balance, £8 0s. 6d., was refunded. Publication of the results of the research has been delayed, but the manuscript is ready for the press.

Professor T. H. Easterfield in 1922 was granted £200 for a research on orchard-fruits. A preliminary account of this research was recently given to the Fruitgrowers' Association, who have also contributed to the cost of the work; the account was published in the *Nelson Evening Mail.*

Professor W. P. Evans in 1918 was granted £200, in 1920 a further £200, and in 1921 a further £200, totalling £600, for a research on New Zealand brown coals. The work covered investigation into the distillates of the various coals as regards fuels for internal-combustion engines and primary chemicals for organic work in general. The Canterbury College Council assisted in supplying part salary of an assistant, the remainder being paid from the grant. A large amount of apparatus was purchased, including a ball mill, electric furnance, &c.; analyses and experiments have been made in connection with the various coals, and the results have been good. A general account of the research was presented at the last meeting of the Australasian Association for the Advancement of Science, and will be published with the report of that meeting.

Professor C. Coleridge Farr in 1919 was granted £100, in 1920 an additional £30, and in 1922 £60, for a research on porcelain insulators. A testing-vessel was constructed, and the tests proved entirely satisfactory. A paper embodying the results was published in the *Journal of the American Institute of Electrical Engineers* (vol. 41, No. 10, Oct., 1922, p. 711), and roused great interest, not only in New Zealand. Critics from Australia and England have spoken most highly of the work. Mr. E. Parry says, "The results are very important, and, what is more, are very much more conclusive than any that have hitherto been published." The unexpended balance is £55 11s. 6d. Professor Farr and Mr Philpott, his assistant, consider that the work has now become of such a practical nature, and so routine in practice, that any further expenditure upon it should be borne by the Public Works Department and not come upon the Research Grants Fund of the New Zealand Institute, which is essentially for investigations of an uncertain and experimental nature. It is considered that the work has progressed beyond that stage and become of a commercial character.

Professor C. Coleridge Farr in 1921 was granted £75, £60 of which was later transferred to his research on insulators, for a research on the physical properties of gas-free sulphur. Work has been progressing, and the expenditure so far has been only very slight. Professor Farr hopes shortly to publish a paper showing the results of his investigations.

Mr. G. Gray in 1920 was granted £50 for a chemical investigation on the waters of Canterbury. There was a delay in fitting up a laboratory and obtaining apparatus, but 130 samples of water has been collected from Lincoln district and from the Selwyn and Waimakariri Rivers. Mr. Gray then found that his health prevented him from carrying on the investigations, and he surrendered the whole of the grant.

The Artesian Wells Committee, with Dr. Hilgendorf as convener, in 1921 was granted £100 for a research into the sources of supply, constancy of flow, &c., of the artesian wells of the Christchurch area. Recorders for reading the static level in wells have been installed. Observations have been completed in Christchurch, and the recorders have been removed to Lincoln. The work during Dr. Hilgendorf's absence was delayed, but it is now being pushed forward. The expenditure incurred was chiefly in shelters for the recorders, piping, &c.

Mr. H. Hill in 1917 was granted £20 for investigations of the Taupo Plain as to whether artesian water may be expected in certain areas. Mr. Hill expended the whole

of the grant in preliminary investigations, and application for a further grant was subsequently withdrawn. A paper by Mr. Hill on the subject of artesian wells has been published in volume 54 of the *Transactions*.

Mr. W. G. Howes in 1919 was granted £30 for a research on the neuropterous fauna. This research was undertaken in company with Dr. Tillyard. Investigations were made in Queenstown, Arthur's Pass, and Moana; the results were good, and a paper dealing with the results of the material gathered is to be submitted. The whole of the grant was expended in travelling-expenses and apparatus.

Sir David Hutchins in 1920 was granted £50 for a research on the growth of native trees, and he obtained valuable data with regard to the growth of rimu, totara, and white pine. Travelling-expenses and apparatus absorbed the whole of the grant, and the work was incomplete when Sir David Hutchins died. A further £25 was granted to enable the notes of the grantee's work to be collated and published. This work is being proceeded with by Mr. F. W. Foster, of the Forestry Department, under the supervision of the Director of the State Forest Service.

Professor R. Jack in 1917 was granted £25 for investigations of the electrical charge on rain and its connections with the meteorological conditions. Professor Jack promises to furnish a report of this research before the end of the year.

Professor H. B. Kirk in 1917 was granted £25 for investigating methods of killing mosquitoes and larvae. The experiments proved that the cresols in the pure state are not very effective, and that neither they nor the phenols are so effective as a mixture of all together. Professor Kirk found no larvaecide of equal efficiency with light oil. Experiments had also been made with tanglefoot mixtures. The grant was expended in travelling expenses, &c. A paper embodying results of this work was published in volume 50 of the *Transactions*.

Messrs. T. L. Lancaster and Cornes in 1919 were granted £50 for an inquiry into the rate and growth of the principal New Zealand timber-trees. Some data on kauri saplings in Titirangi and on the growth-rings was collected, and some observations made in Swanson. Mr. Cornes was removed from Auckland, and owing to pressure of work Mr. Lancaster was unable to continue the work, and the whole grant was surrendered.

Messrs. W. S. La Trobe and C. E. Adams in 1917 were granted £50 towards out-of-pocket expenses in the construction of a tide-predicting machine, for the purpose of increasing the speed and decreasing the cost of predicting tides for New Zealand. Work was previously performed by laborious calculation at considerable cost, and the services of two officers at this duty are necessary to predict the tides for two ports every year. The grant was overexpended, and application was made for an additional £75. Professor Sommerville and Mr. Hogben having reported favourably on the machine, the application was granted by the Standing Committee, but sanction was withheld by the Hon. the Minister.

Professor J. Malcolm in 1918 was granted £30 for a research on the pharmacology of New Zealand plants. As an outcome of this research, a paper dealing with the tutu fruit and seed was published in volume 51 of the *Transactions*, and work on pukateine was progressing, although it had been retarded owing to pressure of University work. Books and apparatus were absorbing the grant.

Professor J. Malcolm in 1919 was granted £250 for a research on the composition of New Zealand fishes. In 1920 a further £175 was granted for this purpose, and was mainly expended in the salary of an assistant. Three papers—Part 1 and Part 2, by Mrs. Johnson, his assistant—were published in volumes 52 and 53 of the *Transactions*, and Part 3, by Professor J. Malcolm and T. B. Hamilton, in volume 55.

Dr. E. Marsden in 1922 was granted a special grant by Internal Affairs of £100 for an investigation of the earthquakes in Taupo. The money was spent on three journeys to Taupo, and on constructing and installing instruments to register the earthquakes. One hundred earthquake records were procured, and are being worked up. The full report on this grant has not yet been presented.

Dr. E. Marsden in 1919 was granted £125 for radium and apparatus for research in the disintegration effect of the impact of α particles on matter. Observations have been made in Samoa and Mount Egmont with the purpose of finding whether it is possible to promote radio-active disintegration. Radium has been purchased and measured, and experiments were directed to ascertain whether or not there is an extra-terrestrial radiation of radio-active nature. A preliminary account of the research has been accepted for publication in the *Journal of Atmospheric Electricity and Terrestrial Magnetism*, and a fuller account is in process of preparation.

Dr. E. Marsden in 1919 was granted £60 for a research on the relative efficiency of coal-gas and electricity for domestic purposes and heating in New Zealand. A paper embodying the results of this research was published in the *Journal of Science*

and Technology (vol. 3, Nos. 5, 6). The research was carried on with the assistance of Miss Fenton, and the grant was expended in apparatus and an honorarium to Miss Fenton.

Dr. E. Marsden in 1920 was granted £50 for a research on the physical properties of New Zealand timbers. So far no report has been received on this grant.

Mr. D. D. Milligan in 1922 was granted £50 for an investigation of orthoptera. Two trips have been made to the north of Auckland and some collection made, but the full report of his work has not yet been received.

Mr. W. G. Morrison in 1919 was granted £100 for a research on the afforestation o the Spenser Ranges. Useful data were collected on a tour through the North Island with Professor Wilson of Harvard, and photographs have been taken. A paper on natural afforestation was prepared for presentation to the Science Congress held in Palmerston North, and an earlier paper on this subject was published in the *Journal of Science and Technology* (vol. 2, Nos. 4, 5). At the end of 1922 Mr. Morrison found he was unable, owing to official duties, to continue the research, and he refunded the unexpended balance.

Dr. D. Petrie in 1917 was granted £20 for an exploration of the grass flora of southern Nelson, &c., but he found he was unable to prosecute the research, and he refunded the grant.

Mr. R. Speight in 1919 was granted £225 for a geological survey of the Malvern Hills. In various parts of the hills experiments have been carried out, some portions showing fair prospects of coal. The examination of the hills is still in progress, and the expenses so far have been confined to field-work, travelling, &c. Preparation for publishing results is being made.

Mr. L. P. Symes in 1916 was granted £50 for an investigation of the causes of deterioration and decay of apples and fruit in cold storage. On account of ill health and pressure of business, Mr. Symes was compelled to surrender the grant.

Mr. H. D. Skinner in 1920 was granted £200 for an ethnographic survey of the South Island. Mr. Beattie was employed as assistant, and the grant was used to pay his salary and expenses. The ground covered was from the Bluff to Kaiapoi, and a large amount of entirely new material relating to Maori life was secured. Mr. Beattie has prepared 750 pages of manuscript embodying the results of this research, and this is waiting publication.

Messrs. R. Speight and L. J. Wild in 1916 were granted £50 for an investigation of the phosphate-yielding rocks of Canterbury. All the localities in Canterbury where it was considered possible that phosphate material might exist in quantity were examined. The work was held up, and, according to resolution of the annual meeting regarding refunding unexpended balances of research grants granted prior to January, 1919, the unexpended portion was refunded. Two papers have been published—one, entitled "The Limestones of Canterbury considered as a Possible Source of Phosphate," in the *Journal of Science and Technology* (vol. 2, No. 3, 1919), and "The Stratigraphical Relationship of the Weka Pass Stone and the Amuri Limestone," in the *Transactions of the New Zealand Institute* (vol. 50).

Dr. J. A. Thomson in 1919 was granted £100 for an investigation into the chemical character of igneous rocks. Owing to Dr. Thomson's continued illness, this research is in abeyance.

Hon. G. M. and Mr. G. S. Thomson in 1919 were granted £50 for a research on the economic value of whale-feed. There was some delay in obtaining apparatus from England, but with its arrival the research was proceeded with, and a paper giving the results of the work was published in the *Journal of Science and Technology* (vol. 6, No. 2, p. 111).

Mr. L. J. Wild in 1918 was granted £30 for a soil-survey in Canterbury. In connection with this Mr. Wild prepared a paper, which was published in the *Journal of Science and Technology* (vol. 3, No. 2), entitled "The Calcium-carbonate Content of some Soils from Canterbury and Southland." The expenses incurred were slight, and the balance was refunded as per resolution of the annual meeting referred to above. Early in 1923 Mr. Wild applied for another grant to enable him to undertake a soil-survey in the Manawatu district. £25 was granted for this purpose on condition that the survey was restricted to that portion of the Manawatu district lying to the north of the Manawatu River.

Mr. A. M. Wright in 1921 was granted £75 for a research on the vitamine-content of commercial meat products. The research is still in progress, and, although the earlier results have been the subject of various lectures, &c., nothing has so far been published. Mr. Wright explains that he had intended publishing in the *Transactions*, but owing to the delay in the issue of the volume he is arranging to publish elsewhere, and hopes to do so before the end of the year. Expenditure has been in books and apparatus.

Grants from the Hutton Memorial Fund.

Dr. C. Chilton in 1911 was granted £10 from the Hutton Fund towards the cost of preparing illustrations for a revision of the New Zealand Crustacea. These illustrations were used in papers published in the *Transactions* (vols. 43 and 44), in *Journal of the Linnean Society* (vol 32), and in *Annals of Natural History* (ser. 8, vol. 18, &c.).

Dr. F. W. Hilgendorf in 1911 was granted £10 for apparatus required for researches on artesian wells in Canterbury. Money was expended in making and fixing apparatus for securing a continuous record of the fluctuations in the height of an artesian well near Christchurch. A further application for £5 was declined. A paper entitled "Fluctuation of Water-level in a Christchurch Artesian Well," by L. Symes, and a paper entitled "Fluctuations in the Water-level of some Artesian Wells in the Christchurch Area," by Dr. Hilgendorf, were published in *Transactions* (vol. 49).

Mr. T. Hall in 1914 was granted £20 for collecting entomological and other specimens of the New Zealand fauna for Dr. Chilton and Major Broun. The grant was used in travelling and other expenses incurred in collecting in the Rakaia Gorge, and in the region of Lake Wakatipu, Routeburn Valley, &c. Coleoptera and other specimens collected were sent to Major Broun and to Dr. Chilton.

Major T. Broun in 1916 was granted £50 towards the publication of his researches on the New Zealand Coleoptera.

Mr. W. R. B. Oliver in 1915 was granted £15 to defray travelling-expenses and cost of apparatus for a visit to Lord Howe Island, undertaken in November, 1913; and in the *Transactions* (vol. 49, pp. 94–161) he published a paper entitled "The Vegetation of Lord Howe Island."

Portobello Marine Fish-hatchery (G. M. Thomson, Esq.) was granted £25 in 1916 for prosecuting research on the distribution of native marine food-fishes. Investigations were carried on, and a pamphlet, written by Mr. Anderton, late curator of the hatchery, and the Hon. G. M. Thomson, on the history of the Portobello Fish-hatchery, contained statements of all that has been done.

In 1919 Miss M. K Mestayer was granted £10 for a research on the New Zealand Mollusca. Some few illustrations for two papers published in the *Transactions* (vols. 51, 53) were prepared for Miss Mestayer with portion of the grant, but for the last two years she has reported that no work has been done.

Dr. C. A. Cotton in 1915 was granted £15 towards an investigation of the physiographic features of the New Zealand coast, but as he obtained a grant from another source he surrendered this grant.

Property-list.

The following is a list of apparatus purchased by the aid of a grant from the Research Fund and in use by the various grantees. When a research is completed the apparatus used in the research is returned to the Institute for use by future research workers.

In the possession of the Institute at present are the following: One block plane, cost 9s.; one camera, £15; one tenon saw, 4s. 6d.

At present in hands of research grantees: Aerial insulators, cost £4 4s.; air-condensors, £12 8s.; altitude and azimuth instrument, £10; analytical balance, £36; ball mill, £23 12s. 9d.; castings, fittings, &c., for same, £56 15s. 8d.; "Big Ben" alarm clocks (2), £3 7s. 6d.; cages (animal), £3; camera, £1 11s.; chemical balance, £37; weights for same, £4 14s. 3d.; condensers, £1 17s. 11d.; Duddell thermogalvanometer, £41 4s.; electric furnace and fittings, £28 15s. 3d.; electric oven, £14 14s. 5d.; eye-piece, £2 16s. 8d.; Kjedahl apparatus, £1 15s.; micrometer eye-piece, £17 2s.; objective prism, £33; oxygen cylinder, 1 28 c. ft., £4 15s. 6d.; photometer, £2 10s.; range-finder, £4; scales and electric motor, £5 10s.; sieve, 8s. 6d.; sphere, £25 15s.; soxhelet apparatus, £1 5s. 4d.; syringe (hypodermic), 6s. 6d.; telephones (one pair), £3 2s.; testing-vessel, porcelain insulators, £95; tide-predicting machine, £63 17s. 6d.; Van Slyke's apparatus, £15.

Publication Committee's Report.—Delay in publication of volume 54: A discussion took place on this delay, and a letter from the Hon. Editor, dated 25th January, 1924, was read. A message was received from Internal Affairs Department that the Government Printer has promised to do his utmost, if all papers are in his hands before the end of January, to have volume 55 published by the end of July, 1924.

On the motion of Mr. Morgan, seconded by Mr. Hudson, it was resolved, That the printing of the *Transactions* for the two years 1922 and 1923 in one volume, No. 55, be entrusted to the Government Printer.

Publication Committee's Report.

At the tim of making this report (19th December, 1923) volume 54 is still unpublished. The early session of 1923 began just before the concluding portion of the volume was finished, and since then one vexatious delay and another has put it off. It was promised by the 14th December, and that date appears on the cover; but work in connection with the British Empire Exhibition, and other work, has again put it off, and it is now promised first thing after the New Year holidays.

The committee has done what it could to expedite the issue of the volume, and can only suggest that the Institute urge the Hon. the Minister to instruct the Printer that the volume is in future to be printed more expeditiously. Details of papers accepted appear in last year's report; it may be added here that the volume consists of xxx plus 920 pages (of which the index comprises 49 pages), 85 plates, and numerous text-figures.

Proceedings of the various societies have not been included; societies failed to send details—some of papers read, some of officers elected; one sent no report at all: moreover, several of the societies print and distribute their own annual report in their own form, and as this printed report is the one sent for insertion in the *Transactions* it was thought unnecessary to duplicate the information.

The text and illustrations of the papers for the following volume ( ) are already in the printer's hands. Forty papers by twenty-seven authors were submitted for publication, but owing to certain authors declining to make suggested alterations, these were reduced to twenty-six papers by twenty-one authors.

These papers will make quite a small volume; and the committee would like to suggest that, as the papers for what would be volume 56 will be in hand by the New Year, the papers for the two years be printed in one volume. This would mean that before the end of 1924 finances will be sound, and publications will have been caught up.

Part 8 (the final) of *Bulletin No. 1* was issued during the year, and Dixon's mosses would also have been issued but for the fact that the plate had been lost by the printer. A new one was obtained, and the bulletin will be out early in the year.

For the Committee.

Johannes C. Andersen.

Pan-Pacific Congress. Report was received. It was resolved, on the motion of the President, That the incoming President be the Institute's representative on the Pan-Pacific Congress Committee.

Report of Pan-Pacific Science Congress.

The second Pan-Pacific Science Congress, to which Dr. Allan Thomson, Dr. P. Marshall, and I had the honour to be the Institute's delegates, opened its Melbourne session on the 13th August, and its Sydney session on the 23rd, concluding there on the 3rd September. In Melbourne the session was opened by the Governor-General, His Excellency the Right Honourable Henry W. B. Forster, and in Sydney by the State Governor, His Excellency Sir William Davidson. The addresses of both were masterly, sympathetic, and cordial. That of Sir William Davidson in particular was eminently classical, and it has still the mournful consideration for us that it was the last public address that he gave. By his death shortly after the Congress concluded science lost a friend and humanity a servant of magnificent gifts and splendid devotion.

The Congress was attended by eminent men from every country that has a Pacific coast, except South American countries, and by eminent men from Britain. Its proceedings were marked by keen devotion to work, and by the great number of important questions that were considered. Its fine effects will be lifelong on many of the delegates and on many of the members of the Australian public. There was, indeed, the keenest interest manifested by the public in all the proceedings. Among the minor advantages may be mentioned the feeling of attraction that was felt and freely expressed by great numbers of overseas delegates for Australia and for the Australian people, and the determination of many of them to revisit it. From this some even material advantage will result to Australia from the liberal subsidy that made the holding of the Congress possible.

Among the general decisions of the Congress was one for the setting-up of an Organization Committee, consisting of representatives of the various Pacific countries and of Great Britain. It falls to the Institute to elect the New Zealand representative.

On the invitation of the delegates from Japan, the next Congress will be held in that country, in 1926.

H. B. Kirk.

Tongariro National Park.—Report was received. On the motion of Dr. Cockayne, seconded by Dr. Allan Thomson, it was resolved, That this Board strongly opposes the planting of heather on any part of the Tongariro National Park, or any other national park or scenic reserve.

On the motion of Mr. Hill, seconded by Dr. Marshall, it was resolved to urge that no leasing of any portion of the National Park be allowed.

Report of Tongariro National Park Board.

As the *ex officio* representative of the Institute on the Tongariro National Park Board, I enclose for the information of the Board of Governors a copy of the report to Parliament.

There are certain matters of policy in connection with the administration of the park on which I think the Institute should come to a conclusion for the guidance of its representative.

A proposal came before the Park Board at its first meeting to lease certain portions of the park for the erection of summer residences. I considered it my duty to oppose this proposal. A conclusion on the matter has not yet been come to.

When the Board was constituted a license was found to be held by the Prisons Department to cut timber on a certain defined area on Hauhangatahi, then brought within the boundaries of the park. The Board was faced with the difficulty of making roads, and of meeting other expenditure, with no settled revenue. It decided to renew the license under strict conditions as to selective logging, and to accept in payment the making of roads by prison labour. It is, I think, desirable that the Institute should lay down, for guidance of its representative, the principle that milling within the park should absolutely cease at the earliest possible date.

Heather has been planted widely on certain of the open portions of the park. When the Park Board was constituted a considerable quantity of heather-seed was on its way from Britain, purchased at the expense of the Robert Bruce Trust. The trustees have given the park £1,000 as a donation to its general fund, with a prospect of a further donation. The Board has given permission for the planting of the seed that was already on the way, and has decided to consider the whole matter before any further planting is allowed. If the Institute decides that it is opposed to the planting of exotics the action of its representative should be firm and decided, but he will need all the tact he may possess.

H. B. Kirk.

Carter Bequest.—A deputation, consisting of Sir Robert Stout, Dr. Newman, Mr. Wright (Mayor of Wellington), Mr. J. P. Maxwell, Mr. Darling, Dr. C. E. Adams, Mr. Berry, Professor Sommerville, and others, waited on the Board with a proposal that the Board should grant £3,000 out of the Carter Fund for the purpose of erecting a building on the site donated by the City Council to house the Meanee 9 in. telescope, which had been recently purchased by the Council for £500, and was now valued at £2,000. Dr. Newman, who introduced the deputation, informed the Board that the Wellington Philosophical Society would be willing to pay the costs of both sides of any friendly action in the Supreme Court to determine the power of the Institute in the matter. Sir Robert Stout also briefly supported Dr. Newman's application. He considered the suggestion that the Institute should become the owners and managers of the telescope and site would produce responsibilities which were outside the functions of the New Zealand Institute.

After the deputation had withdrawn Mr. Eliott moved, and Mr. Wright seconded, and it was carried, That the resolution passed in January, 1923, relating to using £2,000 of the Carter Bequest for assisting the erection of an observatory, be rescinded.

After considerable discussion the following motion, moved by the President, and seconded by the Hon. Treasurer, Mr. Eliott, was carried: That, provided (*a*) all legal difficulties be removed, (*b*) the tenure of the site be assured to the Institute, (*c*) the City Council donate the municipal

telescope to the Institute as trustees of the Carter Fund, there be built a Carter Memorial Observatory at the expense of the Carter Fund; that the observatory be under the control of the New Zealand Institute, exercised through a joint committee of the Institute and the Wellington City Council and the Astronomical Section of the Wellington Philosophical Society; that not more than £3,000 be spent on the building of the observatory, the remainder of the Carter Fund being allowed to accumulate till it is sufficient to found a professorship of astronomy; further, that the Standing Committee be empowered to take such action as may be necessary to carry out these resolutions.

The Hon. Librarian's Report and the Library Agreement were received and adopted.

Hon. Librarian's Report.

At the time of the last annual meeting the books had been removed to Victoria University College, and a beginning had been made to sort them from the hopelessly confused masses that covered the floor. That work was continued throughout the summer recess, and by the end of February the rough sorting was completed and shelving could begin. As it then became impossible to give much of my own time to the work, outside assistance was obtained. On the 6th June, while still huge piles of roughly sorted books lay upon the floor, and an immense amount of heavy work remained to be done, Miss Wood came up to the college, bringing with her the office requisites, and the College became the headquarters of the Institute. The remainder of the work Miss Wood completed practically without aid, she showing a competent energy and determination that deserve special recognition by the Institute. The present position may be stated thus: the books are on the shelves as far as the amount of shelving at present available will permit, and the library has been in working-order since August. Complete cataloguing has still to be done, with the careful examination that this will involve in order to discover what gaps in series exist and with the correspondence necessary to fill those gaps.

The books are, for the most part, on shelving provided by the College; and it seems certain that the amount of shelving taken up to the College by the Institute is considerably less than the amount that it is already using. In terms of its agreement the Institute has to provide for the College an equal amount.

The shelving taken to the college was taken by permission of the Department of Internal Affairs, and the Institute is indebted to Mr. Hislop for the considerate recommendation that made this possible. It is indebted to him also for the kindest assistance in allowing the books to be removed in the Department's motor-van. In consequence of the decision of the Wellington Philosophical Society not to allow its books to leave the Museum, it was necessary to determine ownership, a very difficult task in some cases. This task was undertaken by a joint committee, on which the Institute's representatives were Mr. Aston and Professor Cotton. They had to spend a great deal of time in this difficult work, and they did the work well.

H. B. Kirk,
Hon. Librarian.

Library Agreement.

Memorandum of the terms under which the library of the New Zealand Institute (hereinafter referred to as the Institute), formerly housed at the Dominion Museum, Wellington, and to be now sent to Victoria University College, Wellington (hereinafter referred to as the College), is to be retained at the College.

The said library of the Institute, including all additions which in the future may be made thereto (hereinafter called "the library") is to be forwarded to the College at the sole expense for carriage of the Institute, and to remain at Victoria University College building until either the Board of Governors of the Institute or the Council of the College determine that this arrangement shall be ended and give at least twelve calendar months' notice to that effect to the other body, when the library shall with all convenient speed be removed by the Institute at its sole expense.

The Institute shall forthwith supply shelving which shall be sufficient to accommodate the library. This shall be erected at the College at the expense of the Institute, and may be adapted and used as found necessary for the purposes of the College.

The Assistant Secretary of the Institute shall be a half-time member of the library staff of the College, and shall accordingly attend at the College library for at least half

of his or her working-time. He or she shall be paid by the Institute, but shall during his or her attendance, as above mentioned, at the College be under the direction of the Librarian of the College.

The works now included in the library are all properly stamped with the name of the Institute or otherwise identified, and all additions thereto shall be similarly stamped or identified by the Institute at its expense.

The library shall be properly shelved at the College, but not necessarily kept separate from the works in the College library.

The library is to remain the property of the Institute, but shall be under the control of the Council of the College or its nominees so long as it remains in the College building.

The library shall be available for use by members of the Institute at all times at which the College library is open to students of the College, and at such other reasonable times as the Institute may wish, provided that at these times the books are issued by the assistant provided by the Institute, or by some other person whose responsibility is recognized by the Institute and by the College. Books that are the property of the College may not be issued at these other times. The College may set aside any works in the library of which there are duplicates in the College library, except such sets as may be loaned by the Institute to the Dominion Museum, and store same in the College building. In the case of duplicates stored by the College the rights of members of the Institute shall extend to the copies in the College library.

The Institute will at its own expense bind all magazines at present unbound, proceeding with this work at a reasonable rate. The Institute will also at its own expense and at proper intervals bind all magazines hereinafter added to the library which may reasonably require binding, and will at its own expense effect all necessary repairs to the volumes of the library.

The library may be used by the staff and students of the College.

Members of the New Zealand Institute shall have the same privileges with the Institute's own books as members of the College staff have at the present time with regard to the books belonging to the College library, except that access to the library shall only be at such times as it is officially open. In addition, members of the Institute shall, on application to the Secretary of the Institute, be entitled to receive library cards giving them readers' privileges, as under the Victoria University College Library Regulations 5 (C), p. 65, Calendar 1922.

Books in the library belonging to the New Zealand Institute may be posted on loan to members of the Institute at the expense of the Institute.

The library shall be insured against fire by the Institute, which shall pay all insurance premiums.

The College shall take all reasonable care of the library, but will not be responsible for any loss or damage to same.

Dated this 5th day of February, 1923.

For the Victoria University College:
P. Levi, Chairman of Council.
For the New Zealand Institute:
H. B. Kirk, President.

Samoan Observatory Committee.—The report was received and adopted. The following motion, proposed by Dr. Farr and seconded by Dr. Marshall, was carried: That this Institute, being apprised of the benefit accruing to the Samoan Geophysical Observatory from the setting-up of an advisory board of scientists, recommends that the Government should constitute the same committee as an advisory board on all geophysical and astronomical observatories in New Zealand.

Report of the Samoan Observatory Committee.

I have to state that the co-operation of the four members of the Institute on the above committee with the Government representatives has proceeded smoothly and with excellent results. There is reason to believe that, acting on the advice of the committee, the Department of External Affairs has conducted the Observatory at Samoa in a manner worthy of New Zealand, and satisfactory in every way from a scientific point of view.

The committee receives and comments on the annual report of the Director, and advises the External Affairs Department as to the way in which the money should be spent. The Department of External Affairs has shown a commendable, progressive

and scientific spirit in the way it has treated and assisted the deliberations of the committee.

The committee has regularly met, and has arranged for the publications of the Observatory as well as scientific working.

E. MARSDEN.

Committee on Cataloguing Scientific Periodicals.—The report was received and adopted. On the motion of Dr. Thomson, seconded by Dr. Chilton, it was resolved, That the card catalogue of scientific periodicals should be the property of the Philosophical Institute of Canterbury.

REPORT OF THE COMMITTEE ON THE CATALOGUE OF SCIENTIFIC PERIODICALS.

The last list of periodicals was received a few weeks ago: all entries have now been transferred to a card catalogue. I hope to return from the Chatham Islands sufficiently early in January to enable me to have the manuscript ready by the end of the month.

The reference list will necessarily contain the information in the briefest form, but the card catalogue contains all the relative information supplied to me. It is suggested that libraries desiring a copy of this may obtain a set by paying the cost of the cards and copying, which should be done locally; while the present card catalogue should in fairness belong to the Canterbury Philosophical Institute, which was the instigator of the proposal and whose members have assisted me in its preparation.

GILBERT ARCHEY,
Hon. Editor, Reference List of Periodicals.

Great Barrier Reef Committee.—The report was received and adopted.

REPORT OF THE GREAT BARRIER REEF COMMITTEE.

Since reporting last year the Great Barrier Reef Committee has met five times. The chief business transacted was as follows:—

(1.) Suggestions for the investigation of the New Guinea region of the reef were received from Mr. E. R. Stanley.

(2.) A letter was received from the Director, British Museum (Natural History), London, stating that Dr. W. T. Calman had been appointed to keep in touch with the activities of the committee, and giving many suggestions for carrying out work on the reef.

(3.) Professor H. C. Richards and Mr. C. Hedley explored the reef between Cairns and Thursday Island, and submitted a report on the work done. Further results of their trip will appear through the usual scientific channels.

(4.) A special meeting, attended by several overseas delegates to the Pan-Pacific Science Congress, was held on s.s. "Relief," on the 18th September, 1923, and a programme of investigations was discussed. This was on the occasion of the expedition to the reef of delegates to the Pan-Pacific Science Congress, after the close of the Sydney session.

W. R. B. OLIVER,
New Zealand Institute Representative on Committee.

Fellowship Election.—It was resolved that the number of Fellows to be elected in 1925 be two. A ballot for the election of two Fellows for 1924 resulted in the election of Dr. R. J. Tillyard and Mr. H. Guthrie-Smith.

Hector Prize.—On the motion of Dr. Farr, seconded by Dr. Chilton, it was resolved, That a committee, consisting of the retiring President, the President-elect, and the Hon. Treasurer, be elected to look into the trust deeds of the Hector Memorial Prize and report on the general powers of the Board at next meeting. It was resolved that the amount of the Hector Prize for 1924 be £45.

Honorary Members.—A ballot for the election of three honorary members resulted in the election of Dr. Charles Chree, Mr. Charles Hedley, and Professor Einstein. On the motion of Dr. Thomson, seconded by Professor Kirk, it was resolved, That the Publication Committee be directed to

publish the list of honorary members in alphabetical order, with the date of election following the name. One vacancy declared: The vacancy caused by the death of Professor Bayley Balfour was announced.

National Research Council.—On the motion of Dr. J. Allan Thomson, seconded by Dr. Cockayne, it was resolved, That this meeting, having considered the advisability of forming a National Research Council for New Zealand, is of the opinion that this is unnecessary, since the New Zealand Institute already performs those functions for New Zealand for which National Research Councils have been set up in other countries.

On the motion of Dr. Farr, seconded by Mr. Hill, it was resolved, That the Standing Committee consider how far the functions of the National Research Councils elsewhere are at present fulfilled by the New Zealand Institute.||

Building Fund.—On the motion of Mr. Aston, seconded by Professor Kirk, it was resolved, That this meeting affirms the desirableness of establishing a Building Fund to provide for a building in which to house the property of the Institute, and to hold meetings, and for other purposes.

Carter Legacy.—It was resolved, That the Standing Committee inquire further into the matter of £50 retained by the Public Trustee for erection of a brick room for housing the Carter Library.

Science Congress.—On the motion of the Hon. Mr. G. M. Thomson, seconded by Dr. Malcolm, it was resolved, That the next New Zealand Science Congress be held in Dunedin, in the beginning of 1926.

Dominion Museum.—On the motion of the Hon. Mr. G. M. Thomson, it was resolved, That the Board of Governors of the New Zealand Institute urge upon the Government the advisability of placing the Dominion Museum under the management of a Board of Trustees.

Election of Officers.—President, Dr. P. Marshall; Hon. Secretary, Mr. B. C. Aston; Hon. Treasurer, Mr. M. A. Eliott; Hon. Librarian, Professor Kirk; Hon. Editor, Mr. J. C. Andersen; Hon. Returning Officer, Professor Segar; Managers of Trust Funds, Hon. Secretary and Hon. Treasurer.

Election of Committees.—Research Committee: Mr. B. C. Aston, Professor Evans, Mr. Furkert, and Mr. P. G. Morgan.

Publication Committee: Dr. Cotton, Mr. J. C. Andersen, Professor Marsden, Mr. Aston, and Mr. G. V. Hudson.

Library Committee: Professor Kirk, Professor Sommerville, Dr. Thomson, and Dr. Cotton.

Hector Award Committee: Professor Easterfield and Professor Robertson.

Date and Place of next Annual Meeting.—To be held in last week of January, 1925. Exact date and place to be fixed by the Standing Committee.

Votes of Thanks.—A vote of thanks was passed to the Press for their attendance, to Victoria College Council for the use of the room, and to Professor Kirk, who provided the excellent afternoon tea. This was carried by acclamation. A vote of thanks was also passed to the honorary officers of the Institute for their work during the past year.

APPENDIX.

NEW ZEALAND INSTITUTE ACT, 1908.

1908, No. 130.

An Act to consolidate certain Enactments of the General Assembly relating to the New Zealand Institute.

Be it enacted by the General Assembly of New Zealand in Parliament assembled, and by the authority of the same, as follows:—

1. (1.) The Short Title of this Act is the New Zealand Institute Act, 1908.

(2.) This Act is a consolidation of the enactments mentioned in the Schedule hereto, and with respect to those enactments the following provisions shall apply:—

(*a*.) The Institute and Board respectively constituted under those enactments, and subsisting on the coming into operation of this Act, shall be deemed to be the same Institute and Board respectively constituted under this Act without any change of constitution or corporate entity or otherwise; and the members thereof in office on the coming into operation of this Act shall continue in office until their successors under this Act come into office.

(*b*.) All Orders in Council, regulations, appointments, societies incorporated with the Institute, and generally all acts of authority which originated under the said enactments or any enactment thereby repealed, and are subsisting or in force on the coming into operation of this Act, shall enure for the purposes of this Act as fully and effectually as if they had originated under the corresponding provisions of this Act, and accordingly shall, where necessary, be deemed to have so originated.

(*c*.) All property vested in the Board constituted as aforesaid shall be deemed to be vested in the Board established and recognized by this Act.

(*d*.) All matters and proceedings commenced under the said enactments, and pending or in progress on the coming into operation of this Act, may be continued, completed, and enforced under this Act.

2. (1.) The body now known as the New Zealand Institute (hereinafter referred to as "the Institute") shall consist of the Auckland Institute, the Wellington Philosophical Society, the Philosophical Institute of Canterbury, the Otago Institute, the Hawke's Bay Philosophical Institute, the Nelson Institute, the Westland Institute, the Southland Institute, and such others as heretofore have been or may hereafter be incorporated therewith in accordance with regulations heretofore made or hereafter to be made by the Board of Governors.

(2.) Members of the above-named incorporated societies shall be *ipso facto* members of the Institute.

3. The control and management of the Institute shall be vested in a Board of Governors (hereinafter referred to as "the Board"), constituted as follows:—

The Governor:

The Minister of Internal Affairs:

Four members to be appointed by the Governor in Council, of whom two shall be appointed during the month of December in every year:

Two members to be appointed by each of the incorporated societies at Auckland, Wellington, Christchurch, and Dunedin during the month of December in each alternate year; and the next year in which such an appointment shall be made is the year one thousand nine hundred and nine:

One member to be appointed by each of the other incorporated societies during the month of December in each alternate year; and the next year in which such an appointment shall be made is the year one thousand nine hundred and nine.

4. (1.) Of the members appointed by the Governor in Council, the two members longest in office without reappointment shall retire annually on the appointment of their successors.

(2.) Subject to the last preceding subsection, the appointed members of the Board shall hold office until the appointment of their successors.

5. The Board shall be a body corporate by the name of the "New Zealand Institute," and by that name shall have perpetual succession and a common seal, and may sue and be sued, and shall have power and authority to take, purchase, and hold lands for the purposes hereinafter mentioned.

6. (1.) The Board shall have power to appoint a fit person, to be known as the "President," to superintend and carry out all necessary work in connection with the affairs of the Institute, and to provide him with such further assistance as may be required.

(2.) The Board shall also appoint the President or some other fit person to be editor of the Transactions of the Institute, and may appoint a committee to assist him in the work of editing the same.

(3.) The Board shall have power from time to time to make regulations under which societies may become incorporated with the Institute, and to declare that any incorporated society shall cease to be incorporated if such regulations are not complied with; and such regulations on being published in the *Gazette* shall have the force of law.

(4.) The Board may receive any grants, bequests, or gifts of books or specimens of any kind whatsoever for the use of the Institute, and dispose of them as it thinks fit.

(5.) The Board shall have control of the property from time to time vested in it or acquired by it; and shall make regulations for the management of the same, and for the encouragement of research by the members of the Institute; and in all matters, specified or unspecified, shall have power to act for and on behalf of the Institute.

7. (1.) Any casual vacancy in the Board, howsoever caused, shall be filled within three months by the society or authority that appointed the member whose place has become vacant, and if not filled within that time the vacancy shall be filled by the Board.

(2.) Any person appointed to fill a casual vacancy shall only hold office for such period as his predecessor would have held office under this Act.

8. (1.) Annual meetings of the Board shall be held in the month of January in each year, the date and place of such annual meeting to be fixed at the previous annual meeting.

(2.) The Board may meet during the year at such other times and places as it deems necessary.

(3.) At each annual meeting the President shall present to the meeting a report of the work of the Institute for the year preceding, and a balance-sheet, duly audited, of all sums received and paid on behalf of the Institute.

9. The Board may from time to time, as it sees fit, make arrangements for the holding of general meetings of members of the Institute, at times and places to be arranged, for the reading of scientific papers, the delivery of lectures, and for the general promotion of science in New Zealand by any means that may appear desirable.

10. The Minister of Finance shall from time to time, without further appropriation than this Act, pay to the Board the sum of five hundred pounds in each financial year, to be applied in or towards payment of the general current expenses of the Institute.

11. Forthwith upon the making of any regulations or the publication of any Transactions, the Board shall transmit a copy thereof to the Minister of Internal Affairs, who shall lay the same before Parliament if sitting, or if not, then within twenty days after the commencement of the next ensuing session thereof.

SCHEDULE.

Enactments consolidated.

1903, No. 48.—The New Zealand Institute Act, 1903.

NEW ZEALAND INSTITUTE AMENDMENT ACT, 1920.

1920, No. 3.

AN ACT to amend the New Zealand Institute Act, 1908.

[30th July, 1920

BE IT ENACTED by the General Assembly of New Zealand in Parliament assembled, and by the authority of the same, as follows :-

1. This Act may be cited as the New Zealand Institute Amendment Act, 1920, and shall be read together with and deemed part of the New Zealand Institute Act, 1908.

2. Section ten of the New Zealand Institute Act, 1908, is hereby amended by omitting the words "five hundred pounds," and substituting the words "one thousand pounds."

REGULATIONS.

THE following are the regulations of the New Zealand Institute under the Act of 1903 :—*

The word "Institute" used in the following regulations means the New Zealand Institute as constituted by the New Zealand Institute Act, 1903.

INCORPORATION OF SOCIETIES.

1. No society shall be incorporated with the Institute under the provisions of the New Zealand Institute Act, 1903, unless such society shall consist of not less than twenty-five members, subscribing in the aggregate a sum of not less than £25 sterling annually for the promotion of art, science, or such other branch of knowledge for which it is associated, to be from time to time certified to the satisfaction of the Board of Governors of the Institute by the President for the time being of the society.

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* *New Zealand Gazette*, 14th July, 1904.

2. Any society incorporated as aforesaid shall cease to be incorporated with the Institute in case the number of the members of the said society shall at any time become less than twenty-five, or the amount of money annually subscribed by such members shall at any time be less than £25.

3. The by-laws of every society to be incorporated as aforesaid shall provide for the expenditure of not less than one-third of the annual revenue in or towards the formation or support of some local public museum or library, or otherwise shall provide for the contribution of not less than one-sixth of its said revenue towards the extension and maintenance of the New Zealand Institute.

4. Any society incorporated as aforesaid which shall in any one year fail to expend the proportion of revenue specified in Regulation No. 3 aforesaid in manner provided shall from henceforth cease to be incorporated with the Institute.

Publications.

5. All papers read before any society for the time being incorporated with the Institute shall be deemed to be communications to the Institute, and then may be published as Proceedings or Transactions of the Institute, subject to the following regulations of the Board of the Institute regarding publications :—

(*a.*) The publications of the Institute shall consist of—

(1.) A current abstract of the proceedings of the societies for the time being incorporated with the Institute, to be intituled "Proceedings of the New Zealand Institute";

(2.) And of transactions comprising papers read before the incorporated societies (subject, however, to selection as hereinafter mentioned), and of such other matter as the Board of Governors shall from time to time determine to publish, to be intituled "Transactions of the New Zealand Institute."

(*b.*) The Board of Governors shall determine what papers are to be published.

(*c.*) Papers not recommended for publication may be returned to their authors if so desired.

(*d.*) All papers sent in for publication must be legibly written, typewritten, or printed.

(*e.*) A proportional contribution may be required from each society towards the cost of publishing Proceedings and Transactions of the Institute.

(*f.*) Each incorporated society will be entitled to receive a proportional number of copies of the Transactions and Proceedings of the New Zealand Institute, to be from time to time fixed by the Board of Governors.

Management of the Property of the Institute.

6. All property accumulated by or with funds derived from incorporated societies, and placed in charge of the Institute, shall be vested in the Institute, and be used and applied at the discretion of the Board of Governors for public advantage, in like manner with any other of the property of the Institute.

7. All donations by societies, public Departments, or private individuals to the Institute shall be acknowledged by a printed form of receipt and shall be entered in the books of the Institute provided for that purpose, and shall then be dealt with as the Board of Governors may direct.

Honorary Members.

8. The Board of Governors shall have power to elect honorary members (being persons not residing in the Colony of New Zealand), provided that the total number of honorary members shall not exceed thirty.

9. In case of a vacancy in the list of honorary members, each incorporated society, after intimation from the Secretary of the Institute, may nominate for election as honorary member one person.

10. The names, descriptions, and addresses of persons so nominated together with the grounds on which their election as honorary members is recommended, shall be forthwith forwarded to the President of the New Zealand Institute, and shall by him be submitted to the Governors at the next succeeding meeting.

General Regulations.

11. Subject to the New Zealand Institute Act, 1908, and to the foregoing rules, all societies incorporated with the Institute shall be entitled to retain or alter their own form of constitution and the by-laws for their own management, and shall conduct their own affairs.

12. Upon application signed by the President and countersigned by the Secretary of any society, accompanied by the certificate required under Regulation No. 1, a certificate of incorporation will be granted under the seal of the Institute, and will remain in force as long as the foregoing regulations of the Institute are complied with by the society.

13. In voting on any subject the President is to have a deliberate as well as a casting vote.

14. The President may at any time call a meeting of the Board, and shall do so on the requisition in writing of four Governors.

15. Twenty-one days' notice of every meeting of the Board shall be given by posting the same to each Governor at an address furnished by him to the Secretary.

16. In case of a vacancy in the office of President, a meeting of the Board shall be called by the Secretary within twenty-one days to elect a new President.

17. The Governors for the time being resident or present in Wellington shall be a Standing Committee for the purpose of transacting urgent business and assisting the officers.

18. The Standing Committee may appoint persons to perform the duties of any other office which may become vacant. Any such appointment shall hold good until the next meeting of the Board, when the vacancy shall be filled.

19. The foregoing regulations may be altered or amended at any annual meeting, provided that notice be given in writing to the Secretary of the Institute not later than the 30th November.

The following additional regulations, and amendment to regulations, were adopted at a general meeting of the Board of Governors of the New Zealand Institute, held at Wellington on the 30th January, 1918, and at Christchurch on the 3rd February, 1919. (See *New Zealand Gazette*, No. 110, 4th September, 1919.)

Regulations governing the Fellowship of the Institute.

20. The Fellowship of the New Zealand Institute shall be an honorary distinction for the life of the holder.

21. The Original Fellows shall be twenty in number, and shall include the past Presidents and the Hutton and Hector Medallists who have held their distinctions and positions prior to 3rd February, 1919, and who at that date are members of the Institute. The remaining Original Fellows shall be nominated as provided for in Regulation 26 (*a*), and shall be elected by the said past Presidents and Hector and Hutton Medallists.

22. The total number of Fellows at any time shall not be more than forty.

23. After the appointment and election of the Original Fellows, as provided in Regulation 21, not more than four Fellows shall be elected in any one year.

24. The Fellowship shall be given for research or distinction in science.

25. No person shall be elected as Fellow unless he is a British subject and has been a member of one of the incorporated societies for three years immediately preceding his election.

26. After the appointment and election of the Original Fellows as provided in Regulation 21 there shall be held an annual election of Fellows at such time as the Board of Governors shall appoint. Such election shall be determined as follows:—

(*a*.) Each of the incorporated societies at Auckland, Wellington, Christchurch, and Dunedin may nominate not more than twice as many persons as there are vacancies, and each of the other incorporated societies may nominate as many persons as there are vacancies. Each nomination must be accompanied by a statement of the qualifications of the candidate for Fellowship.

(*b*.) Out of the persons so nominated the Fellows resident in New Zealand shall select twice as many persons as there are vacancies, if so many be nominated.

(*c*.) The names of the nominees shall be submitted to the Fellows at least six months, and the names selected by them submitted to the Governors at least three months, before the date fixed for the annual meeting of the Board of Governors at which the election is to take place.

(*d*.) The election shall be made by the Board of Governors at the annual meeting from the persons selected by the Fellows.

(*e*.) The methods of selection in subclause (*b*) and of election in subclause (*d*) shall be determined by the Board of Governors.

(*f*.) The official abbreviation of the title "Fellow of the New Zealand Institute" shall be "F.N.Z.Inst."

Amendment to Regulations.

Regulation 5 (*a*) of the regulations published in the *New Zealand Gazette* of the 14th July, 1904, is hereby amended to read:—

"(*a*.) The publications of the Institute shall consist of—

"(1.) Such current abstract of the proceedings of the societies for the time being incorporated with the Institute as the Board of Governors deems desirable;

"(2.) And of transactions comprising papers read before the incorporated societies or any general meeting of the New Zealand Institute (subject, however, to selection as hereinafter mentioned), and of such other matter as the Board of Governors shall from time to time for special reasons in each case determine to publish, to be intituled *Transactions of the New Zealand Institute.*"

THE HUTTON MEMORIAL MEDAL AND RESEARCH FUND.

Declaration of Trust.

This deed, made the fifteenth day of February, one thousand nine hundred and nine (1909), between the New Zealand Institute of the one part, and the Public Trustee of the other part: Whereas the New Zealand Institute is possessed of a fund consisting now of the sum of five hundred and fifty-five pounds one shilling (£555 1s), held for the purposes of the Hutton Memorial Medal and Research Fund on the terms of the rules and regulations made by the Governors of the said Institute, a copy whereof is hereto annexed: And whereas the said money has been transferred to the Public Trustee for the purposes of investment, and the Public Trustee now holds the same for such purposes, and it is expedient to declare the trusts upon which the same is held by the Public Trustee:

Now this deed witnesseth that the Public Trustee shall hold the said moneys and all other moneys which shall be handed to him by the said Governors for the same purposes upon trust from time to time to invest the same upon such securities as are lawful for the Public Trustee to invest on, and to hold the principal and income thereof for the purposes set out in the said rules hereto attached.

And it is hereby declared that it shall be lawful for the Public Trustee to pay all or any of the said moneys, both principal and interest, to the Treasurer of the said New Zealand Institute upon being directed so to do by a resolution of the Governors of the said Institute, and a letter signed by the Secretary of the said Institute enclosing a copy of such resolution certified by him and by the President as correct shall be sufficient evidence to the Public Trustee of the due passing of such resolution: And upon receipt of such letter and copy the receipt of the Treasurer for the time being of the said Institute shall be a sufficient discharge to the Public Trustee: And in no case shall the Public Trustee be concerned to inquire into the administration of the said moneys by the Governors of the said Institute.

As witness the seals of the said parties hereto, the day and year hereinbefore written.

Resolutions of Board of Governors.

Resolved by the Board of Governors of the New Zealand Institute that—

1. The funds placed in the hands of the Board by the committee of subscribers to the Hutton Memorial Fund be called "The Hutton Memorial Research Fund," in memory of the late Captain Frederick Wollaston Hutton, F.R.S. Such fund shall consist of the moneys subscribed and granted for the purpose of the Hutton Memorial, and all other funds which may be given or granted for the same purpose.

2. The funds shall be vested in the Institute. The Board of Governors of the Institute shall have the control of the said moneys, and may invest the same upon any securities proper for trust-moneys

3. A sum not exceeding £100 shall be expended in procuring a bronze medal to be known as "The Hutton Memorial Medal."

4. The fund, or such part thereof as shall not be used as aforesaid, shall be invested in such securities as aforesaid as may be approved of by the Board of Governors, and the interest arising from such investment shall be used for the furtherance of the objects of the fund.

5. The Hutton Memorial Medal shall be awarded from time to time by the Board of Governors, in accordance with these regulations, to persons who have made some noticeable contribution in connection with the zoology, botany, or geology of New Zealand.

6. The Board shall make regulations setting out the manner in which the funds shall be administered. Such regulations shall conform to the terms of the trust.

7. The Board of Governors may, in the manner prescribed in the regulations, make grants from time to time from the accrued interest to persons or committees who require assistance in prosecuting researches in the zoology, botany, or geology of New Zealand.

8. There shall be published annually in the *Transactions of the New Zealand Institute* the regulations adopted by the Board as aforesaid, a list of the recipients of the Hutton Memorial Medal, a list of the persons to whom grants have been made during the previous year, and also, where possible, an abstract of researches made by them.

Regulations under which the Hutton Memorial Medal shall be awarded and the Research Fund administered.

1. Unless in exceptional circumstances, the Hutton Memorial Medal shall be awarded not oftener than once in every three years; and in no case shall any medal be awarded unless, in the opinion of the Board, some contribution really deserving of the honour has been made.

2. The medal shall not be awarded for any research published previous to the 31st December, 1906.

3. The research for which the medal is awarded must have a distinct bearing on New Zealand zoology, botany, or geology.

4. The medal shall be awarded only to those who have received the greater part of their education in New Zealand or who have resided in New Zealand for not less than ten years.

5. Whenever possible, the medal shall be presented in some public manner.

6. The Board of Governors may, at any annual meeting, make grants from the accrued interest of the fund to any person, society, or committee for the encouragement of research in New Zealand zoology, botany, or geology.

7. Applications for such grants shall be made to the Board before the 30th September.

8. In making such grants the Board of Governors shall give preference to such persons as are defined in regulation 4.

9. The recipients of such grants shall report to the Board before the 31st December in the year following, showing in a general way how the grant has been expended and what progress has been made with the research.

10. The results of researches aided by grants from the fund shall, where possible, be published in New Zealand.

11. The Board of Governors may from time to time amend or alter the regulations, such amendments or alterations being in all cases in conformity with resolutions 1 to 4.

Award of the Hutton Memorial Medal.

1911. Professor W. B. Benham, D.Sc.. F.R.S., University of Otago—For researches in New Zealand zoology.

1914. Dr. L. Cockayne, F.L S., F R.S.—For researches on the ecology of New Zealand plants.

1917. Professor P. Marshall, M.A , D.Sc.—For researches in New Zealand geology.

1920. Rev John E. Holloway, D.Sc.—For researches in New Zealand pteridophytic botany.

1923. J. Allan Thomson, M.A., D.Sc., F.G.S., F.N.Z.Inst --For researches in geology.

Grant from the Hutton Memorial Research Fund

1919 Miss M. K. Mestayer—£10, for work on the New Zealand Mollusca.

1923. Professor P. Marshall, M.A., D.Sc., F.N.Z.Inst.—£40, for study of Upper Cretaceous ammonites of New Zealand.

HECTOR MEMORIAL RESEARCH FUND.

Declaration of Trust.

This deed, made the thirty-first day of July, one thousand nine hundred and fourteen, between the New Zealand Institute, a body corporate duly incorporated by the New Zealand Institute Act, 1908, of the one part, and the Public Trustee of the other part: Whereas by a declaration of trust dated the twenty-seventh day of January, one thousand nine hundred and twelve, after reciting that the New Zealand Institute was possessed of a fund consisting of the sum of £1,045 10s. 2d., held for the purposes of the Hector Memorial Research Fund on the terms of the rules and regulations therein mentioned, which said moneys had been handed to the Public Trustee for investment, it was declared (*inter alia*) that the Public Trustee should hold the said moneys and all other moneys which should be handed to him by the said Governors of the Institute for the same purpose upon trust from time to time, to invest the same in the common fund of the Public Trust Office, and to hold the principal and income thereof for the purposes set out in the said rules and regulations in the said deed set forth: And whereas the said rules and regulations have been amended by the Governors of the New Zealand Institute, and as amended are hereinafter set forth: And whereas it is expedient to declare that the said moneys are held by the Public Trustee upon the trusts declared by the said deed of trust and for the purposes set forth in the said rules and regulations as amended as aforesaid:

Now this deed witnesseth and it is hereby declared that the Public Trustee shall hold the said moneys and all other moneys which shall be

handed to him by the said Governors for the same purpose upon trust from time to time to invest the same in the common fund of the Public Trust Office, and to hold the principal and income thereof for the purposes set out in the said rules and regulations hereinafter set forth:

And it is hereby declared that it shall be lawful for the Public Trustee to pay, and he shall pay, all or any of the said moneys, both principal and interest, to the Treasurer of the said New Zealand Institute upon being directed to do so by a resolution of the Governors of the said Institute, and a letter signed by the Secretary of the said Institute enclosing a copy of such resolution certified by him and by the President as correct shall be sufficient evidence to the Public Trustee of the due passing of such resolution: And upon receipt of such letter and copy the receipt of the Treasurer for the time being of the said Institute shall be a sufficient discharge to the Public Trustee: And in no case shall the Public Trustee be concerned to inquire into the administration of the said moneys by the Governors of the said Institute.

As witness the seals of the said parties hereto, the day and year first hereinbefore written.

Rules and Regulations made by the Governors of the New Zealand Institute in relation to the Hector Memorial Research Fund.

1. The funds placed in the hands of the Board by the Wellington Hector Memorial Committee be called "The Hector Memorial Research Fund," in memory of the late Sir James Hector, K.C.M.G., F.R.S. The object of such fund shall be the encouragement of scientific research in New Zealand, and such fund shall consist of the moneys subscribed and granted for the purpose of the memorial and all other funds which may be given or granted for the same purpose.

2. The funds shall be vested in the Institute. The Board of Governors of the said Institute shall have the control of the said moneys, and may invest the same upon any securities proper for trust-moneys.

3. A sum not exceeding one hundred pounds (£100) shall be expended in procuring a bronze medal, to be known as the Hector Memorial Medal.

4. The fund, or such part thereof as shall not be used as aforesaid, shall be invested in such securities as may be approved by the Board of Governors, and the interest arising from such investment shall be used for the furtherance of the objects of the fund by providing thereout a prize for the encouragement of such scientific research in New Zealand of such amount as the Board of Governors shall from time to time determine.

5. The Hector Memorial Medal and Prize shall be awarded annually by the Board of Governors.

6. The prize and medal shall be awarded by rotation for the following subjects, namely—(1) Botany, (2) chemistry, (3) ethnology, (4) geology, (5) physics (including mathematics and astronomy), (6) zoology (including animal physiology).

In each year the medal and prize shall be awarded to that investigator who, working within the Dominion of New Zealand, shall in the opinion of the Board of Governors have done most towards the advancement of that branch of science to which the medal and prize are in such year allotted.

7. Whenever possible the medal shall be presented in some public manner.

Award of the Hector Memorial Research Fund.

1912. L. Cockayne, Ph.D., F.L.S., F.R.S.—For researches in New Zealand botany.
1913. T. H. Easterfield, M.A., Ph.D.—For researches in chemistry.
1914. Elsdon Best—For researches in New Zealand ethnology.
1915. P. Marshall, M.A., D.Sc., F.G.S.—For researches in New Zealand geology.
1916. Sir Ernest Rutherford, F.R.S.—For researches in physics.
1917. Charles Chilton, M.A., D.Sc., F.L.S., C.M.Z.S.—For researches in zoology.
1918. T. F. Cheeseman, F.L.S., F.Z.S.—For researches in New Zealand systematic botany.
1919. P. W. Robertson—For researches in chemistry.
1920. S. Percy Smith—For researches in New Zealand ethnology.
1921. R. Speight, M.A., M.Sc., F.G.S.—For work in New Zealand geology.
1922. C. Coleridge Farr, D.Sc.—For research in physical science, and more particularly work in connection with the magnetic survey of New Zealand.
1923. G. V. Hudson, F.E.S., F.N.Z.Inst.—For researches in New Zealand entomology.
1924. D. Petrie, M.A., F.N.Z.Inst.—For researches in New Zealand botany.

REGULATIONS FOR ADMINISTERING THE GOVERNMENT RESEARCH GRANT.*

All grants shall be subject to the following conditions, and each grantee shall be duly informed of these conditions:—

1. All instruments, specimens, objects, or materials of permanent value, whether purchased or obtained out of or by means of the grant, or supplied from among those at the disposal of the Institute, are to be regarded, unless the Research Grants Committee decide otherwise, as the property of the Institute, and are to be returned by the grantee, for disposal according to the orders of the committee, at the conclusion of his research, or at such other time as the committee may determine.

2. Every one receiving a grant shall furnish to the Research Grants Committee, on or before the 1st January following upon the allotment of the grant, a report (or, if the object of the grant be not attained, an interim report, to be renewed at the same date in each subsequent year until a final report can be furnished or the committee dispense with further reports), containing (*a*) a brief statement showing the results arrived at or the stage which the inquiry has reached; (*b*) a general statement of the expenditure incurred, accompanied, as far as is possible, with vouchers; (*c*) a list of the instruments, specimens, objects, or materials purchased or obtained out of the grant, or supplied by the committee, which are at present in his possession; and (*d*) references to any transactions, journals, or other publications in which results of the research have been printed. In the event of the grantee failing to send in within three months of the said 1st January a report satisfactory to the committee he may be required, on resolution of the Board of Governors, to return the whole of the sum allotted to him.

* In addition to these regulations the Standing Committee is also bound by certain resolutions which appear on page 536 of volume 49, *Trans. N.Z. Inst.*, and which grantees are also bound to observe.

3. Where a grant is made to two or more persons acting as a committee for the purpose of carrying out some research, one member of the said committee shall assume the responsibility of furnishing the report and receiving and disbursing the money.

4. Papers in which results are published that have been obtained through aid furnished by the Government grant should contain an acknowledgment of that fact.

5. Every grantee shall, before any of the grant is paid to him, be required to sign an engagement that he is prepared to carry out the general conditions applicable to all grants, as well as any conditions which may be attached to his particular grant.

6. In cases where specimens or preparations of permanent value are obtained through a grant the committee shall, as far as possible, direct that such specimens shall be deposited in a museum or University college within the province where the specimens or material were obtained, or in which the grantee has worked. The acknowledgment of the receipt of the specimens by such institution shall fully satisfy the claims of the Institute.

7. In cases where, after completion of a research, the committee directs that any instrument or apparatus obtained by means of the grant shall be deposited in an institution of higher learning, such deposit shall be subject to an annual report from the institution in question as to the condition of the instrument or apparatus, and as to the use that has been made of it.

Research Grants made for Period ending December, 1923.

Through the Auckland Institute:

Professor F. P. Worley, £25 for chemistry of the essential oils and other products of the New Zealand flora.

Through the Wellington Philosophical Society:—

Dr. C. E. Adams, £20 for completing purchase of astronomical instruments.

Mr. F. Foster, £25 for collating the notes and manuscripts of the late Sir D. E. Hutchins.

Mr. H. Hamilton, £30 for research on the cave fauna of New Zealand.

Mr. E. K. Lomas, £25 for research on the intelligence of school-children.

Dr. E. Marsden, £100 for investigating the Taupo earthquakes.

Mr. J. G. Myers, £10 for research on New Zealand Hemiptera.

Through the Philosophical Institute of Canterbury:—

Dr. H. H. Allan, £30 for research on economic strains in rye-grasses and cocksfoot.

Dr. C. C. Farr, £30 for research on the relationship of radium-emanation and goitre.

Through the Otago Institute:—

Mr. H. J. Finlay, £10 for researches in palaeontology.

Professor J. K. Inglis, £25 for research on essential oils of native plants.

Through the Wanganui Philosophical Society:-

Dr. P. Marshall, £50 for research on Upper Cretaceous fauna of New Zealand.

N.B.—The above grants were made from moneys refunded by other grantees.

THE CARTER BEQUEST.

For extracts from the will of Charles Rooking Carter see vol. 48, 1916, pp. 565–66.

NEW ZEALAND INSTITUTE, 1923.

ESTABLISHED UNDER AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND INTITULED THE NEW ZEALAND INSTITUTE ACT, 1867; RECONSTITUTED BY AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND INTITULED THE NEW ZEALAND INSTITUTE ACT, 1903, AND CONTINUED BY THE NEW ZEALAND INSTITUTE ACT, 1908.

BOARD OF GOVERNORS.

EX OFFICIO.

His Excellency the Governor-General.
The Hon. the Minister of Internal Affairs.

NOMINATED BY THE GOVERNMENT.

Dr. Charles Chilton, F.L.S., C.M.Z.S., F.N.Z.Inst. (reappointed December, 1922); Dr. J. Allan Thomson, F.G.S., F.N.Z.Inst. (reappointed December, 1921); Mr. B. C. Aston, F.I.C., F.C.S., F.N.Z.Inst. (reappointed December, 1921); Dr. Leonard Cockayne, F.R.S., F.L.S., F.N.Z.Inst. (reappointed December, 1922).

ELECTED BY AFFILIATED SOCIETIES, 1921.

Wellington Philosophical Society ...	Professor E. Marsden, D.Sc., F.N.Z.Inst. Professor C. A. Cotton, D.Sc., F.G.S., F.N.Z.Inst.
Auckland Institute	Professor H. W. Segar, M.A., Ph.D., F.N.Z.Inst. Professor F. P. Worley, D.Sc.
Philosophical Institute of Canterbury ...	F. W. Hilgendorf, M.A., D.Sc., F.N.Z.Inst. (elected 1922). Mr. A. M. Wright, A.I.C., F.C.S.
Otago Institute	Hon. G. M. Thomson, F.L.S., F.N.Z.Inst., M.L.C. Mr. W. G. Howes, F.E.S.
Hawke's Bay Philosophical Institute ...	Mr. H. Hill, B.A., F.G.S.
Nelson Institute	R. J. Tillyard, M.A., D.Sc., F.L.S., F.E.S.
Manawatu Philosophical Society ...	Mr. M. A. Eliott.
Wanganui Philosophical Society ..	P. Marshall, M.A., D.Sc., F.G.S., F.N.Z.Inst.
Poverty Bay Institute	Ven. Archdeacon H. W. Williams, M.A.

OFFICERS FOR THE YEAR 1923.

President: Professor H. B. Kirk, M.A., F.N.Z.Inst.
Hon. Treasurer: Mr M. A. Eliott.
Hon. Editor: Mr. Johannes C. Andersen, F.N.Z.Inst.
Hon. Librarian: Professor C. A. Cotton, D.Sc., F.G.S., F.N.Z.Inst.
Hon. Secretary: Mr. B. C. Aston, F.I.C., F.C.S., F.N.Z.Inst. (Box 40, Post-office, Wellington).
Hon. Returning Officer: Professor H. W. Segar, M.A., Ph.D., F.N.Z.Inst.

AFFILIATED SOCIETIES, 1922–23.

Name of Society.	Secretary's Name and Address.	Date of Affiliation.
Wellington Philosophical Society	E. K. Lomas, Training College, Kelburn, Wellington	10th June, 1868.
Auckland Institute ..	T. F. Cheeseman, Auckland Institute and Museum, Auckland	10th June, 1868.
Philosophical Institute of Canterbury	C. E. Foweraker, Canterbury College, Christchurch.	22nd October, 1868.
Otago Institute	Wm. Martin, Musselburgh Rise, Dunedin	18th October, 1869.
Hawke's Bay Philosophical Institute	C. F. H. Pollock, P.O. Box 301, Napier	31st March, 1875.
Nelson Institute	Mrs. Margaret Graham, Nelson	20th December, 1883.
Manawatu Philosophical Society	Chas. T. Salmon, P.O. Box 293, Palmerston North	6th January, 1905.
Wanganui Philosophical Society	J. P. Williamson, P.O. Box 171, Wanganui	2nd December, 1911.
Poverty Bay Institute ..	John Mouat, Gisborne ..	1st February, 1919.

NEW ZEALAND INSTITUTE, 1924.

ESTABLISHED UNDER AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND INTITULED THE NEW ZEALAND INSTITUTE ACT, 1867; RECONSTITUTED BY AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND INTITULED THE NEW ZEALAND INSTITUTE ACT, 1903, AND CONTINUED BY THE NEW ZEALAND INSTITUTE ACT, 1908

BOARD OF GOVERNORS.

EX OFFICIO.

His Excellency the Governor-General.
The Hon. the Minister of Internal Affairs.

NOMINATED BY THE GOVERNMENT.

Dr. Charles Chilton, F.L.S., C.M.Z.S., F.N.Z.Inst. (reappointed December, 1922); Dr. J. Allan Thomson, F.G.S., F.N.Z.Inst. (reappointed December, 1923); Mr. B. C. Aston, F.I.C., F.C.S., F.N.Z.Inst. (reappointed December, 1923); Dr. Leonard Cockayne, F.R.S., F.L.S., F.N.Z.Inst. (reappointed December, 1922).

ELECTED BY AFFILIATED SOCIETIES, 1923.

Wellington Philosophical Society ...	Mr. G. V. Hudson, F.E.S., F.N.Z.Inst. Mr. P. G. Morgan, M.A., F.G.S., F.N.Z.Inst.
Auckland Institute	Professor H. W. Segar, M.A., Ph.D., F.N.Z.Inst. Professor F. P. Worley, D.Sc.
Philosophical Institute of Canterbury...	Professor C. Coleridge Farr, D.Sc., F.P.S.L., F.N.Z.Inst. Mr. A. M. Wright, A.I.C., F.C.S.
Otago Institute	Hon. G. M. Thomson, F.L.S., F.N.Z.Inst., M.L.C. Professor J. Malcolm, M.D.
Hawke's Bay Philosophical Institute ...	Mr. H. Hill, B.A., F.G.S.
Nelson Institute	Professor T. H. Easterfield, M.A., Ph.D., F.I.C., F.N.Z. Inst.
Manawatu Philosophical Society ...	Mr. M. A. Eliott.
Wanganui Philosophical Society ...	P. Marshall, M.A., D.Sc., F.G.S., F.N.Z Inst.

OFFICERS FOR THE YEAR 1924.

PRESIDENT: Dr. P. Marshall, M.A., F.G.S., F.N.Z.Inst.
HON. TREASURER: Mr. M. A. Eliott.
HON. EDITOR: Mr. Johannes C. Andersen, F.N.Z.Inst.
HON. LIBRARIAN: Professor H. B. Kirk, M.A., F.N.Z.Inst.
HON. SECRETARY: Mr. B. C. Aston, F.I.C., F.C.S., F.N.Z.Inst.
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AFFILIATED SOCIETIES, 1923–24.

Name of Society.	Secretary's Name and Address.	Date of Affiliation.
Wellington Philosophical Society	E. K. Lomas, Training College, Kelburn, Wellington	10th June, 1868.
Auckland Institute ..	(Acting) L. T. Griffin, The Museum, Auckland	10th June, 1868.
Philosophical Institute of Canterbury	C. E. Foweraker, Canterbury College, Christchurch	22nd October, 1868.
Otago Institute	F. H. McDowall, Knox College, Dunedin	18th October, 1869.
Hawke's Bay Philosophical Institute	C. F. H. Pollock, P.O. Box 301, Napier	31st March, 1875.
Nelson Institute	Mis. Margaret Graham, Nelson	20th December, 1883.
Manawatu Philosophical Society	Chas. T. Salmon, P.O. Box 293, Palmerston North	6th January, 1905.
Wanganui Philosophical Society	J. P. Williamson, P.O. Box 171, Wanganui	2nd December, 1911.

FORMER MANAGER AND EDITOR.

[UNDER THE NEW ZEALAND INSTITUTE ACT, 1867.]

1867–1903.

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1913–14.

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Original Fellows.

(See *New Zealand Gazette*, 20th November, 1919.)

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*†Cheeseman, Thomas Frederick, F.L.S., F.Z.S. §
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Park, Professor James, M.Am.Inst.M.E., M.Inst.M.M., F.G.S.

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Schofield, Mrs. G. H., Sefton Street, Wadestown.
Seelye, F. T., Dominion Laboratory, Wellington.
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Smith, R. D., 39 Willis Street, Wellington.
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Sunley, R. M., View Road, Karori.
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Thomson, J. Allan, M.A., D.Sc., F.G.S., F.N.Z.Inst., Dominion Museum, Wellington.
Thomson, P., Solicitor, Stratford.
Thomson, W. M., M.A., M.B., Ch.B., Hawera.
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Tolley, H. R., 66 Hankey Street, Wellington.
Tombs, H. H., Burnell Avenue, Wellington.
Tomkies, A. E., Chief Electrical Line Inspector, N.Z. Railways.
Toogood, H. F., 11 Grey Street, Wellington.
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Turner, E. Phillips, F.R.G.S., Forestry Department, Wellington.
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Waghorn, R. J., Technical High School, Hastings.
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Warner, —, School-teacher, Upper Hutt.
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Widdop, F. C., District Railway Engineer, Thorndon Office, Wellington.
Wilson, Sir James G., Bulls.
Wood, J., Inspecting Engineer, Public Works Department, Wellington.
Wyles, G. W., Assistant Signal Engineer, Railways, Wellington.
Wynne, H. J., Railway Department, Wellington.
Yates, G., 460 Adelaide Road, Wellington.

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SERIAL PUBLICATIONS RECEIVED BY THE LIBRARY OF THE NEW ZEALAND INSTITUTE, 1923.

NEW ZEALAND.

Auckland University: *Calendar.*
Geological Survey: *Bulletins.*
Houses of Parliament: *Journals* and *Appendix.*
Journal of Agriculture.
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New Zealand Employers' Federation: *Industrial Bulletin.*
New Zealand Official Year-book.
Polynesian Society: *Journal.*
Statistics of New Zealand.

AUSTRALIA.

Australasian Association for the Advancement of Science: *Report.*
Australasian Institute of Mining Engineers: *Proceedings.*
Australian Antarctic Expedition, 1911–14: *Reports.*
Australian Forestry Journal.
Commonwealth of Australia, Fisheries: *Parliamentary Report.*

NEW SOUTH WALES.

Agricultural Department, N.S.W.: *Agricultural Gazette.*
Australian Museum, Sydney: *Records; Annual Report.*
Botanic Gardens and Government Domains, N.S.W.: *Report.*
Critical Revision of the Genus Eucalyptus.
Linnean Society of N.S.W.: *Proceedings.*
Northern Engineering Institute of N.S.W.: *Papers.*
Public Health Department, N.S.W.: *Annual Report.*

QUEENSLAND.

Geological Survey of Queensland: *Publications.*
Queensland Naturalist.
Royal Geographical Society: *Journal.*
Royal Society of Queensland: *Proceedings.*

SOUTH AUSTRALIA.

Adelaide Chamber of Commerce: *Annual Report.*
Department of Chemistry, South Australia: *Bulletins.*
Mines Department and Geological Survey of South Australia: *Mining Operations; G.S. Bulletins and Reports; Metallurgical Reports; Synopsis of Mining Laws.*
Public Library, Museum, and Art Gallery of South Australia: *Annual Report.*
Royal Society of South Australia: *Transactions and Proceedings.*

TASMANIA.

Royal Society of Tasmania: *Papers and Proceedings.*

Victoria.

Advisory Committee: *Report on Brown Coal.*
Department of Agriculture: *Journal.*
Field Naturalists' Club of Victoria: *Victorian Naturalist.*
Mines Department and Geological Survey of Victoria: *Annual Report; Bulletins; Records.*
Public Library, Museum, and National Art Gallery of Victoria: *Annual Report.*
Royal Society of Victoria: *Proceedings.*

Western Australia.

Geological Survey of Western Australia: *Bulletins.*
Royal Society of Western Australia: *Journal and Proceedings.*

United Kingdom.

Board of Agriculture and Fisheries: *Fishery Investigations.*
Botanical Society of Edinburgh: *Transactions and Proceedings.*
British Association for the Advancement of Science: *Report.*
British Astronomical Association: *Journal; Memoirs; List of Members.*
British Museum: *Catalogues; Guides; Scientific Reports of British Antarctic Expedition, 1910.*
Cambridge Philosophical Society: *Proceedings.*
Cambridge University Library: *Report.*
Department of Scientific and Industrial Research: *Reports.*
Dove Marine Library: *Report.*
Geological Society, London: *Quarterly Journal.*
Geological Survey of Great Britain: *Summary of Progress.*
Handbooks, Commercial Towns, England.
Imperial Institute: *Bulletins.*
Institution of Civil Engineers: *Report.*
Leeds Philosophical and Literary Society: *Annual Report*
Linnean Society: *Journal* (Botany); *Proceedings; List of Members.*
Liverpool Biological Society: *Proceedings.*
Liverpool Geological Society: *Proceedings.*
Marine Biological Association: *Journal.*
Marlborough College Natural History Society: *Reports.*
Mercantile Guardian, London.
Mineralogical Society: *Mineralogical Magazine.*
North of England Institute of Mining and Mechanical Engineers: *Transactions; Annual Report.*
Oxford University: *Calendar.*
Royal Anthropological Institute of Great Britain: *Journal.*
Royal Botanic Gardens, Edinburgh: *Notes.*
Royal Colonial Institute: *United Empire.*
Royal Geographical Society: *Geographical Journal.*
Royal Philosophical Society of Glasgow: *Proceedings.*
Royal Physical Society of Edinburgh: *Proceedings.*
Royal Scottish Geographical Society: *Scottish Geographical Magazine.*
Royal Society, Dublin: *Economic Proceedings.*
Royal Society of Edinburgh: *Proceedings; Transactions.*
Royal Society, London: *Proceedings* (Series A, B); *Phil. Trans.* (Series A, B); *Year-book.*

Royal Society of Literature: *Transactions.*
Royal Statistical Society, London: *Journal.*
Victoria Institute, London: *Journal of Transactions.*
Zoological Society of London: *Proceedings and Transactions*

Austria.

Hofmuseum, Wien.
K.K. Central Anstalt für Meteorologie und Erdkunde. Vienna.
K.K. Geologischen Reichlanstalt, Vienna: *Verhandl; Jahrb.*
K.K. Naturhistorischen Hofmuseums, Vienna: *Annalen.*
K.K. Zoologisch-Botanische Gesellschaft, Vienna: *Verhandl.*

Belgium.

Académie Royale de Belgique: *Bulletins.*
Librairie Nationale d'Art et d'Histoire: *Les Cahiers belges.*
Société Royale de Botanique de Belgique: *Bulletins.*
Société Royale Zoologique et Malacologique de Belgique: *Annales*

Denmark.

Acad. Roy. de Sciences et de Lettres de Denmark: *Fordhandlinger; Memoires.*
Dansk. Naturh. Foren., Kjöbenhavn: *Videnskabelige Meddelelser.*
Kong. Dansk. Videnskab. Selskab.: *Forhandlinger; Skrifter.*
Zoological Museum, Copenhagen: *Danish-Ingolf Expedition.*

Finland.

Academia Aboensis, Abo: *Humaniora.*
Finska Vetenskaps-Societeten: *Acta; Ofersigt; Bidrag.*

France.

Le Prince Bonaparte, 10 Avenue d'Jena: *Notes.*
L'Observatoire Météorologique, Paris: *Annales.*
Musée d'Histoire Naturelle, Paris: *Bulletins.*
Société Astronomique France: *Bulletin.*
Société de Chimie Industrielle, Paris: *Chimie et industries.*
Société de Géographie: *La Géographie.*
Société Zoologique de France: *Bulletin.*

Germany.

Botanische Verein der Provinz Brandenburg: *Verhandl.*
Deutsches Entomologisches Museum, Berlin.
Ethnological Institute, Tubingen.
Konigl. Zool. u. Anthro.-Ethno. Museum, Dresden.
K.K. Zentral-Anstalt für Meteorologie und Geodynamik: *Jahrb.*
Naturhistorisches Museum, Hamburg: *Mitth.*
Naturhistorische Verein der Preussischen Rheinlande und Westfalens, Bonn: *Verhandlungen; Sitzungsberichte.*
Naturwissenschaftliche Verein für Schleswig-Holstein: *Schriften.*
Physikalisch-Okonomische Gesellschaft, Konisberg: *Schriften.*
Senkenbergische Naturforschende Gesellschaft, Frankfurt-am-Main: *Berichte.*
Staats und Universitatsbibliothek, Hamburg.
Verhandlungen der Naturforschenden Gesellschaft in Basel.

Holland and Dutch East Indies.

Banka Tin : *Jaaresverslag* von de Winning.
Koninklijke Naturkundige Vereeniging in Nederlandsch-Inde.
Mijnwesen in Nederlandsh Oest-Indie, Batavia : *Jaarbook.*
Nederlandsche Entomologische Vereeniging : *Tydschrift.*
Rijks Ethnographisch Museum, Leiden : *Verslag.*

Italy.

Giornale Botanico Italiano, Nuevo.
Laboratorio di Zoologia Generale E. Agraria, Portice, Naples.
Reale Società Geographica, Roma : *Bollettino.*
Revista Geographica Italiana.
Società Africana d'Italia : *Bollettino.*
Societa Botanica Italliana, Firenze : *Bollettino.*
Società Toscana di Scienze Naturali, Pisa : *Processi verbali.*

Norway.

Bergens Museum : *Aarbok ; Aarberetning.*
Norwegian Meteorologischen Instituts, Kristiana : *Jahrb.*

Russia.

Biological Station, Saratov.

Spain.

Junta de Ciences Naturals de Barcelona : *Series botanica, geologica.*

Sweden.

Botaniska Notiser, Lund.
Kungl Svenska Vetenskapademiens, *Arkiv* for
Meteorologiske Iakttealser i Sverige.
Sverigeo Geologiska-Undersokning : *Arsbok*

Switzerland.

Musee d'Histoire Naturelle, Geneve.
Naturforschende Gesellschaft, Basel.
Naturforschende Gesellschaft, Bern : *Mittheilungen.*
Societa Elvetica delle Scienze Naturali, Bern : *Atti.*
Société de Physique et d'Histoire Naturelle de Geneve.

India and Ceylon.

Agricultural Department, Calcutta : *Report on Progress of Agriculture.*
Agricultural Research Institute and College, Pusa : *Report.*
Asiatic Society of Bengal, Calcutta.
Board of Scientific Advice : *Annual Report.*
Colombo Museum ; *Spolia Zeylanica.*
Geological Survey of India : *Records and Memoirs.*

Japan.

Icones Plantarum Formosanarum, Yaihoku.
Imperial Earthquake Investigation Committee, Tokyo : *Bulletin.*
Imperial University of Tokyo : *Journal of the College of Science.*
Tohoku Imperial University, Sendai : *Science Reports.*

Malay States.

Java Ethnographischen Reichsmuseums : *Katalog.*
Malay States Government Gazette.

Africa.

Durban Museum, Natal: *Annals.*
Natal Museum, Pietermaritzburg: *Annals.*
South African Association for the Advancement of Science: *South African Journal of Science.*
South African Museum: *Annals.*
Transvaal Museum: *Annals.*

Canada.

Department of Naval Service: *Annual Report; Tide Tables.*
Department of the Interior: *Dominion Observatory Reports.*
Mines Department, Geological Survey Branch: *Memoirs; Summary Report; Museum Bulletin.*
Mines Department, Mines Branch: *Bulletins; Annual Report;* other publications.
Nova Scotian Institute of Science, Halifax: *Proceedings*
Royal Canadian Institute, Toronto: *Transactions.*
Royal Society, Canada: *Proceedings and Transactions*

United States.

Academy of Natural Sciences, Philadelphia: *Proceedings.*
American Academy of Arts and Sciences: *Proceedings.*
American Geographical Society, New York: *Geographical Review.*
American Institute of Mining Engineers: *Transactions.*
American Journal of Philology.
American Museum of Natural History, New York: *Bulletins*
American Philosophical Society: *Proceedings.*
Arnold Arboretum of Harvard University: *Journal.*
Astronomical Society of the Pacific, San Francisco.
Astrophysical Journal
Boston Society of Natural History: *Proceedings, Memoirs, &c.*
Brooklyn Institute of Arts and Sciences: *Bulletins.*
Buffalo Society of Natural Sciences: *Bulletin.*
Californian Academy of Sciences: *Proceedings.*
Chicago University: *Journal of Geology.*
Connecticut Academy of Arts and Sciences: *Transactions; Memoirs.*
Cornell University Agricultural Station: *Memoirs; Bulletins*
Department of Registration and Education, State of Illinois: *Bulletin.*
Field Museum of Natural History, Chicago.
Franklin Institute: *Journal.*
Industrial and Engineering Chemistry: *Journal.*
Johns Hopkins University, Baltimore: *Studies; Circulars; Journal.*
Journal of Geology, Chicago.
Leland Stanford Junior University: *Publications.*
Library of Congress, Washington: *Report.*
Lick Observatory, University of California.
Lloyd Library, Ohio: *Index.*
Maryland Geological Survey: *Reports.*
Minnesota University and Geological Survey: *Agricultural Experiment Station Bulletin.*
Missouri Botanical Gardens: *Annals.*
Missouri Bureau of Geology and Mines: *Reports.*

Museum of Comparative Zoology, Harvard: *Bulletin; Annual Report; Memoirs.*
Mycological Notes, Cincinnati.
National Academy of Sciences: *Proceedings.*
New York Academy of Sciences: *Annals.*
New York State College of Agriculture.
Ohio Journal of Science.
Ohio State University: *Bulletin.*
Rochester Academy of Sciences: *Proceedings.*
Smithsonian Institution and U.S. National Museum: *Annual Report; Miscellaneous Collections; Contributions to Knowledge; Bulletins; Contributions from U.S. National Herbarium.*
Tufts College: *Studies (Scientific Series).*
U.S. Department of Agriculture: *Journal of Agricultural Research; Monthly List of Publications.*
U.S. Department of Agriculture, Bureau of Biological Survey: *North American Fauna; Bulletins.*
U.S. Geological Survey: *Annual Report; Professional Papers; Mineral Resources; Bulletins; Water-supply Papers.*
U.S. National Research Council: *Bulletins.*
United States Naval Observatory: *Annual Report.*
University of California: *Bulletin of Department of Geology.*
University of Washington.
Wagner Free Institute of Science: *Transactions.*
Wisconsin Academy of Sciences: *Transactions.*

ARGENTINE.

Academia Nacional de Ciencias: *Boletin.*

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Da Escola Agricultura Rio de Janeiro
Museo Nacional Rio de Janiero: *Archives*
Observatorio de Rio de Janeiro.

MEXICO.

Instituto Geologico de Mexico: *Anales.*

PERU.

Cuerpo de Ingenieros de Minas del Peru: *Boletin.*

HAWAII.

Bishop Museum: *Memoirs.*

PHILIPPINES.

Bureau of Science: *Philippine Journal of Science*

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Société d'Études Oceanniennes: *Bulletin.*

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" Biological Laboratory, University College, Auckland.
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" Canterbury Public Library, Christchurch.
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" Polynesian Society, New Plymouth.
" Portobello Fish-hatchery, Dunedin.
" Reefton School of Mines.
" Southland Museum, Invercargill.
" Thames School of Mines.
" University College, Auckland.
" University of Otago, Dunedin.
" Victoria University College, Wellington.
" Waihi School of Mines, Waihi.
" Wanganui Museum.
" Wellington Philosophical Society.

Great Britain.

Athenæum Subject Index to Periodicals, 11 Bream's Buildings, Chancery Lane, London E.C.
Bodleian Library, Oxford University.
British Association for the Advancement of Science, London.
British Museum Library, London.
〃 Natural History Department, South Kensington London S.W.
Cambridge Philosophical Society, Cambridge University.
Colonial Office, London.
Clifton College, Bristol, England.
Geological Magazine, London.
Geological Society, Synod Hall, Castle Terrace, Edinburgh.
〃 London.
Geological Survey of the United Kingdom, London.
Geological Survey Office, Hume Street, Dublin.
High Commissioner for New Zealand, London.
Imperial Bureau of Entomology, 89 Queen's Gate, London S.W. 7.
Imperial Institute, London.
Institution of Civil Engineers, London.
International Catalogue of Scientific Literature, 34 Southampton Street, Strand, London.
Leeds Geological Association, Sunnyside, Crossgate, Leeds.
Linnean Society, London.
Literary and Philosophical Society, Liverpool.
Liverpool Biological Society.
Marine Biological Association of the United Kingdom, Plymouth.
Natural History Society, Glasgow.
Nature, The Editor of, London.
Norfolk and Norwich Naturalist Society, Norwich.
North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne.
Patent Office Library, 25 Southampton Street, London W.C.
Philosophical Society of Glasgow.
Royal Anthropological Institute of Great Britain and Ireland, 59 Great Russell Street, London W.C.
Royal Botanic Garden Library, Edinburgh.
Royal Colonial Institute, London.
Royal Gardens, Kew, England.
Royal Geographical Society, Kensington Gore, London S.W.
Royal Institution, Liverpool.
Royal Irish Academy, Dublin.
Royal Physical Society, Edinburgh.
Royal Scottish Geographical Society, Synod Hall, Castle Terrace, Edinburgh.
Royal Society, Dublin.
〃 Edinburgh.
〃 London.
Royal Society of Literature of the United Kingdom, London.
Royal Statistical Society, London.
University Library, Cambridge, England.
〃 Edinburgh.
Victoria University, Manchester.
Victoria Institute, London.
Wheldon and Wesley, Ltd., London (Agents).
Zoological Society, London.

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Geological and Natural History Survey of Canada, Ottawa.
Hamilton Scientific Association, Hamilton, Canada.
Institute of Jamaica, Kingston, Jamaica.
International Institute of Agriculture, Department of Agriculture, Ottawa, Canada.
Library, Advisory Research Council, Ottawa, Canada.
Natural History Society of New Brunswick, St. John's.
Nova-Scotian Institute of Natural Science, Halifax.
Royal Canadian Institute, Toronto.

South Africa.

Durban Museum, Natal.
Free Public Library, Cape Town.
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Rhodesia Museum, Bulawayo, South Africa.
South African Association for the Advancement of Science, Cape Town.
South African Museum, Cape Town.

India.

Asiatic Society of Bengal, Calcutta.
Colombo Museum, Ceylon.
Geological Survey of India, Calcutta.
Natural History Society, Bombay.
Raffles Museum, Singapore.

Queensland.

Geological Survey Office, Brisbane.
Queensland Museum, Brisbane.
Royal Society of Queensland, Brisbane.

New South Wales.

Agricultural Department, Sydney.
Australasian Association for the Advancement of Science, Sydney.
Australian Museum Library, Sydney.
Consulate-General of the Czecho-Slovak Republic, Sydney.
Department of Mines, Sydney.
Engineering Association of New South Wales, Sydney.
Engineering Institute of New South Wales, Watt Street, Newcastle.
Library, Botanic Gardens, Sydney.
Linnean Society of New South Wales, Sydney.
Public Library, Sydney.
Royal Society of New South Wales, Sydney.
University Library, Sydney.

Victoria.

Advisory Council of Science and Industry, 314 Albert Street, East Melbourne.
Australian Institute of Mining Engineers, Melbourne.
Commonwealth Institute of Science and Industry, Danks Buildings, 391 Bourke Street, Melbourne.

Field Naturalists' Club, Melbourne.
Geological Survey of Victoria, Melbourne.
Legislative Library, Melbourne.
National Herbarium of Victoria, South Yarra
National Museum, Melbourne.
Royal Society of Victoria, Melbourne.
University Library, Melbourne.

Tasmania.

Public Library of Tasmania, Hobart.
Royal Society of Tasmania, Hobart.

South Australia.

Public Museum and Art Gallery of South Australia, Adelaide.
Royal Society of South Australia, Adelaide.
University Library, Adelaide.

Western Australia.

Government Geologist, Perth.

Russia.

Biological Station, Saratov.
Emperor Peter I Agricultural Institute, Woronesh.
Imper. Moskofskoie Obshchestvo Iestestvo-Ispytatelei (Imperial Moscow Society of Naturalists).
Kiefskoie Obshchestvo Iestestvo-Ispytatelei (Kief Society of Naturalists).

Norway.

Adviser of Norwegian Fisheries, Bergen.
Bergens Museum, Bergen.
University of Christiania.

Sweden.

Geological Survey of Sweden, Stockholm.
Royal Academy of Science, Stockholm.
Universitetsbiblioteket, Uppsala.

Denmark.

Natural History Society of Copenhagen.
Royal Danish Academy of Sciences and Literature of Copenhagen.

Germany.

Biologisches Zentralblatt, Berlin, Dahlem.
Botanischer Verein der Provinz Brandenburg, Berlin.
Deutsches Entomologisches Museum, Berlin.
Ethnological Institute, Tubingen.
Königliche Physikalisch-Oekonomische Gesellschaft, Konigsberg, E. Prussia.
Königliches Zoologisches und Anthropologisch-Ethnographisches Museum, Dresden.
Naturhistorischer Verein, Bonn.
Naturhistorischer Museum, Hamburg.
Naturwissenschaftlicher Verein, Bremen.

Naturwissenschaftlicher Verein, Frankfurt-an-der-Oder.
Prussische Bibliothek, Berlin.
Rautenstrauch-Joest-Museum (Städtisches Museum für Völkerkunde) Cologne.
Redaction des Biologischen Centralblatts, Erlangen.
Senckenbergische Naturforschende Gesellschaft, Frankfurt-am-Main.
Staats und Universitatsbibliothek, Hamburg.
Staatliches Forschungsinstitut für Volkerkunde, Leipzig.
Verein für Vaterländische Naturkunde in Württemburg, Stuttgart.
Zoological Society, Berlin

Finland.

Abo Akademi, Abo.
Finska Vetenskats Societes, Helsingfors.

Austria.

Intendanz des Naturhistorische Hofmuseums, Vienna.
K.K. Central-Anstalt für Meteorologie und Erdmagnetismus, Vienna.
K.K. Geologische Reichsanstalt, Vienna.

Hungary.

Zoological Department, National Museum, Budapest.

Belgium and the Netherlands.

Académie Royal des Sciences, des Lettres, et des Beaux-Arts de Belgique, Brussels.
La Société Royale de Botanique de Belgique, Brussels.
Musée Teyler, Haarlem.
Netherlands Entomological Society, Plantage, Middenlaan 15, Amsterdam.

Switzerland.

Naturforschende Gesellschaft (Société des Sciences Naturelles), Bern.
Societe de Physique et d'Histoire Naturelle de Geneve.

France.

Bibliothèque Nationale, Paris.
Musée d'Histoire Naturelle, Paris.
Société Zoologique de France, Paris.
Société de Chimie Industrielle, 49 Rue de Mathurins, Paris.

Italy.

Biblioteca ed Archivio Tecnico, Rome.
Laboratorio di Zoologica Generale e Agraria, Portici, Naples.
Museo Civice di Storia Naturale, Genova.
Museo di Zoologia e di Anatomia Comparata della R. Universita, Turin.
R. Accademia dei Lincei, Rome.
R. Accademia di Scienze, Lettre, ed Arti, Modena.
Società Africana d'Italia, Naples.
Società Botanica Italiana, Florence.
Società Geografica Italiana, Rome.
Società Toscana di Scienze Naturali, Pisa.
Stazione Zoologica di Napoli, Naples.

Spain.

Junta de Ciencies Naturals, Barcelona, Apartado 593.

United States of America.

Academy of Natural Sciences, Buffalo, State of New York.
" Davenport, Iowa.
" Library, Philadelphia.
" San Francisco.
American Engineering Societies' Library, 29 West 39th Street, New York.
American Geographical Society, New York.
American Journal of Science (Editors), Yale University, New Haven, Conn.
American Philosophical Society, Philadelphia.
Arnold Arboretum, Harvard University, Jamaica Plains, U.S.A.
Astronomical Society of the Pacific, San Francisco.
Boston Society of Natural History.
Brooklyn Botanical Gardens, New York.
Chemical Abstracts, Ohio State University, Columbus, Ohio.
Connecticut Academy, New Haven.
Department of Agriculture, Washington, D.C.
Field Museum of Natural History, Chicago.
Franklin Institute, Philadelphia.
Johns Hopkins University, Baltimore.
Journal of Geology (Editors), University of Chicago, Chicago, Ill.
Leland Stanford Junior University, California.
Library, Bureau of Science, Manila.
Lloyd Library, Cincinnati.
Missouri Botanical Gardens, St. Louis, Mo.
Museum of Comparative Zoology, Cambridge, Mass.
National Academy of Sciences, Smithsonian Institution, Washington, D.C.
National Geographic Society, Washington, D.C.
New York Academy of Sciences, 77th Street and Central Park West, New York.
New York State College of Agriculture, Ithaca, New York.
Rochester Academy of Sciences.
Smithsonian Institution, Washington, D.C.
Tufts College, Massachusetts.
United States Geological Survey, Washington, D.C.
University of California, Berkeley, U.S.A.
University of Illinois, Urbana, Illinois
University of Minnesota, Minneapolis.
University of Montana, Missoula.
University of Washington, Seattle.
Wagner Free Institute of Science of Philadelphia.
Wisconsin Academy of Sciences, Arts, and Letters, Madison.

Brazil.

Escola de Minas, Rio de Janeiro.
Museu Paulista, Sao Paulo.

Argentine Republic.

Academia Nacional de Ciencias, Cordoba.
Museo Nacional de Historia Natural de Buenos Aires, Casilla del Correro
Sociedad Cientifica Argentina, Buenos Ayres.

Uruguay.

Museo Nacional, Monte Video.

Japan.

College of Science, Imperial University of Japan, Tokyo.

Hawaii.

Bernice Pauahi Bishop Museum, Honolulu.
National Library, Honolulu
Volcano Observatory, Kilauea, Hawaii Islands.

Java.

Society of Natural Science, Batavia.

GENERAL INDEX.

[The Editor will be obliged if authors and other users of the index will notify him of any errors or omissions discovered, or make any suggestions for improvements.]

INDEX OF AUTHORS.

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